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Surface and Upper-Air Measurements Acquired During Central California Ozone Study (CCOS)

Final Data Report (Contract 01-2CCOS) (Revised)

Prepared for:

**The San Joaquin Valleywide Study Agency
and
California Air Resources Board**

Prepared by:

**Don Lehrman
Bill Keifer
Technical & Business Systems, Inc.**

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Disclaimer

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1. INTRODUCTION

Technical & Business Systems, Inc. (T&B Systems) installed and operated several types of air quality and meteorological monitoring instruments during the Central California Ozone Study (CCOS). In cooperation with members of the California Air Resources Board (ARB), Bay Area Air Quality Management District (BAAQMD), Sacramento Metropolitan Air Quality Management District (SMAQMD), and San Joaquin Unified Air Pollution Control District (SJUAPCD), locations were selected to address specific gaps in our knowledge of the relative contributions of transport within and between adjacent air basins to the overall central California ambient levels of ozone and ozone precursors. Our responsibilities included surface ozone and NO_y measurements to augment the existing network in the eastern San Francisco Bay area, and upper air meteorological and ozone measurements from the Sacramento, Fresno, and Livermore Valley areas.

The CCOS field measurement program was conducted in the summer of 2000. A complete discussion of the measurements, monitoring network, and overall operations is provided by Fujita, et al. (2001). During CCOS T&B Systems operated ozone analyzers at three sites, NO_y analyzers at two sites, and Doppler acoustic sounding systems (SODAR) at three sites in known pollutant transport corridors between the Bay Area and Central Valley. In addition, T&B Systems performed periodic balloon-borne ozone (ozonesonde) and meteorological (rawinsondes) measurements from sites downwind of the greater Sacramento and Fresno metropolitan areas.

As the CCOS field study progressed, T&B Systems participated in the daily conference calls and regularly reported the network status to the CCOS Field Manager. Continuous measurements (surface ozone, surface NO_y, and SODAR winds) were monitored on a regular basis. Ozonesonde measurements were made on a scheduled basis during intensive operational periods (IOP). Quality assurance procedures followed standard ARB/EPA or manufacturer protocol as required. At the conclusion of the study, the data were validated to level 1A and submitted to the CCOS data manager for inclusion to the integrated master database.

Another element of CCOS consisted of "Supplemental" air quality measurements that were required in key areas of the CCOS modeling domain. Sites were located both where monitoring data were not currently available and at several existing monitoring sites to increase the extent of chemical speciation information. T&B Systems participated in these supplemental measurements at several sites. Our activities for this task are reported by Fujita et al. (2001).

In this report, descriptions are provided for the equipment utilized for the surface and aloft air quality and meteorological measurements. Operations are summarized for each type of measurement. Quality assurance and data validation steps are described.

2. SITE LOCATIONS AND INSTRUMENTATION

T&B Systems installed and operated several monitoring systems during CCOS:

- Ozone Analyzers at three locations
- NO_y Analyzers at two locations
- Ozonesonde/Rawinsondes at two locations
- SODARs at three locations

Thermo Environmental Instruments Inc. (TEI) (formerly TECO and noted as TECO in this document) Model 49C ozone analyzers were provided to T&B Systems by the Bay Area Air Quality Management District. The analyzers were interfaced to Campbell Scientific CR10 data loggers provided by T&B Systems. A Dasibi Model 1008 ozone calibration system cross-referenced against the BAAQMD transfer standard was utilized for station calibrations. TECO Model 40CY NO_y analyzer systems were provided by the BAAQMD as well. At one site, the NO_y analyzer was interfaced to the Campbell Scientific CR10 data loggers. The second NO_y monitoring location was an existing BAAQMD site and the NO_y data was stored using the station data system. Complete descriptions and specifications are provided in Sections 2.1.1 and 2.1.2 below for ozone and NO_y, respectively.

T&B Systems ozone monitoring locations were Kregor Peak, Lake Chabot, and Camp Parks. T&B Systems was responsible for NO_y monitoring at Lake Chabot and Livermore. T&B Systems also assisted BAAQMD staff in the installation of ozone and NO_y instrumentation in a mobile sampling van, and provided calibrations of the analyzers. **Figure 2-1** is a map showing the locations of each of the above sites.

The Kregor Peak location is a routine BAAQMD meteorological monitoring site. The ozone analyzer, data system, and communications were housed in an air-conditioned radio transmitting facility. At Lake Chabot the equipment was housed in an air-conditioned office in a maintenance yard courtesy of the East Bay Regional Park staff. The BAAQMD operates a meteorological station adjacent to the maintenance yard. The equipment at Camp Parks (Livermore Valley) was collocated with the STI radar profiler/RASS electronics in an air-conditioned mobile office. One NO_y analyzer was installed at the BAAQMD network site at Rincon/Livermore.

Measurements of the vertical structure of ozone, temperature, relative humidity and winds were taken at Parlier and Granite Bay using ozonesonde/rawinsonde instrumentation. Both Parlier and Granite Bay were CCOS Research Sites. Descriptions and specifications of the equipment are given in Section 2.1.3 below. **Figure 2-2** is a map showing the locations of the ozonesonde sites.

Continuous measurements of winds aloft using SODAR were made at Livermore Airport, Sunol, and Dublin Canyon. AeroVironment (AV) Model 2000 SODAR systems were operated at the first two locations. At Dublin Canyon an AV Model 4000 SODAR system was utilized. The equipment is described in Section 2.1.4 below. Sunol was a CCOS Research site strategically located at the convergence of flows from Fremont and San Jose areas. The Livermore Airport unit was located more or less in the center of the Livermore Valley. The Dublin Canyon site measured flows in the major transport corridor from the Castro Valley/East Bay to Livermore Valley.



Figure 2-1. Site Locations for CCOS 2000

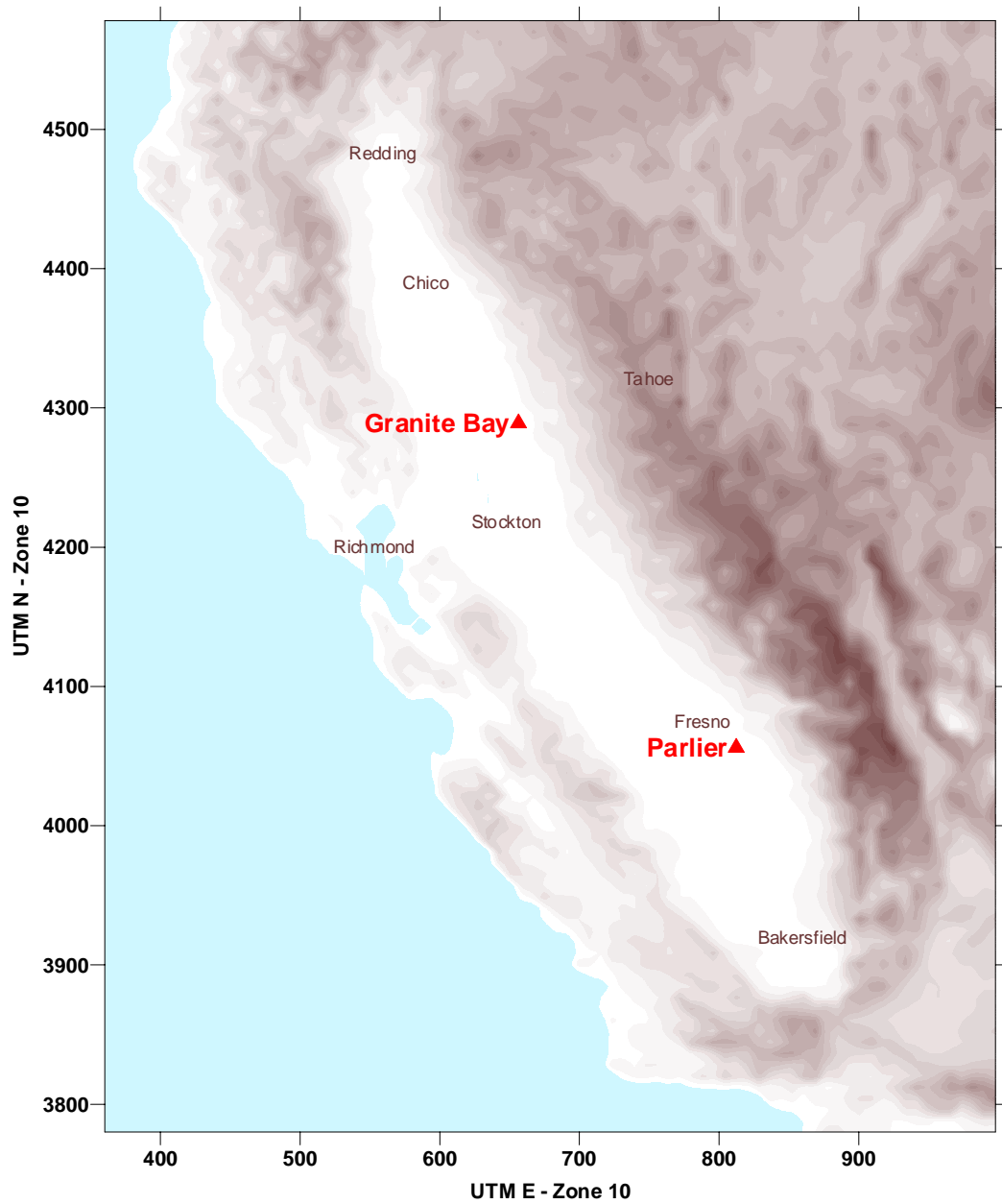


Figure 2-2. Ozonesonde Site Locations

2.1 Instrumentation Descriptions

2.1.1 Ozone Analyzer

The TEI (TECO) Model 49C is a U.V. photometric based ambient ozone analyzer. It is certified as a US EPA Designated Method (EQOA-0880-047). Instrument specifications are shown in **Table 2-1**. User programmable software capabilities allow for selection of frequency at which internal zero/span activation and instrument calibration checks will occur. Additionally, field programmable measurement range settings can be stored in memory for subsequent recall. Of particular utility was the extended troubleshooting diagnostics which provided instantaneous indication of instrument operating parameter, status including: pressure, flow, DC supply voltages, optical bench temperature, ozonator power supply voltage and lamp voltage.

Table 2-1. TECO Model 49C Ozone Specifications

Ranges	0-50, 100, 200, 500, 1000 ppb and 0-1, 2, 5, 10, 20, 100, 200 ppm
Zero Noise	0.5 ppb RMS
Lower Detection Limit	1.0 ppb
Zero Drift	(24 hour) <1 ppb/24 hour, < 2 ppb/7day
Span Drift	less than 1% per month (including drift of transducer)
Response Time	20 sec (10 seconds lag time)
Precision	1 ppb
Linearity	+/- 1% full scale
Sample Flow Rate	2 liter/min. std; (1-3 Lpm option)
Operating Temperature	20-30°C (may be safely operated over the range of 0-45°C)
Power Requirements	90-110VAC; 105-125 VAC, 60Hz; 220-240 VAC, 50 Hz, 150 Watts
Physical Dimensions	16.75" (W) x 8.62" (H) x 23" (D)
Weigh	35 lbs.
Output	Selectable voltages and RS-232 or RS-485 (standard)

2.1.2 NO_y Analyzer

A TECO Model 42CY Trace Level NO-NO₂-NO_x Analyzer was installed and operated at two T&B Systems' sites. This particular analyzer is utilized for high sensitivity air monitoring. This instrument is considered to represent the state-of-the-art subambient chemiluminescence measurement. Due to a combination of hardware design, plumbing arrangement, and software development, the Model 42CY Trace Level can achieve detection limits of 50 ppt or better without sacrificing fast response, ease-of-operation, or cost effectiveness. Instrument specifications are shown in **Table 2-2**.

The Model 42CY Trace Level utilizes a single reaction chamber and photomultiplier tube that are time-multiplexed for NO, NO_x, and zero measurement. The difference between the three measurements allows the generation of three continuous signals of NO, NO₂, and NO_x. Since the Model 42CY Trace Level measures zero continuously, there is virtually no zero drift.

In the NO_y configuration used in this project, the Model 42CY Trace Level is modified to allow more accurate monitoring of total reactive oxides of nitrogen, for example nitric acid (HNO₃) and peroxyacetyl nitrate (PAN). A molybdenum converter is used upstream of its normal location in order to minimize any NO_y losses.

Table 2-2. TECO Model 42CY NO/NO_x/NO_y Specifications

Ranges	0-5, 10, 20, 50, 100, and 200 ppb
Linearity	+/- 1% of full scale
Zero Noise	25 ppt RMS (120 sec avg time)
Lower Detectable Limit (LDL)	50 ppt (120 sec avg time)
Zero Drift (24 hour)	Negligible
Span Drift (24 hour)	+/- 1% of full scale
Response Time (0 - 95%) (Automatic Mode)	60 sec (10 sec avg time); 90 sec (60 sec avg time); 300 sec (300 sec avg time)
Sample Flow Rate	1 LPM
Interferences	propylene rejection ratio > 20,000:1 ethylene rejection ratio>40,000:1
Operating Temperature	20-30°C
Power Requirements	90-100 VAC, 105-125 VAC, 210-250 VAC, 100 watts
Size and Weight	16.75" (W) x 8.62" (H) x 23" (D), 60 lbs

2.1.3 Ozonesonde Systems

Three major components comprise the ozonesonde systems used in CCOS; the W-9000 receiver, Microsonde, and ECC ozonesonde.

VIZ W-9000

The VIZ W-9000 system consists of a VIZ ZEEMET W-9000 navaid ground-based receiver/data system and the VIZ Mark II Microsondes radiosonde packages.

The VIZ ZEEMET W-9000 receiving station interfaces with a personal computer and printer. The UHF receiver operates in the 400 MHZ range. VIZ software enables the interface with the VIZ W-9000 receiver and reduces the thermodynamic pressure, temperature and humidity (PTU) and navaid/wind data. During each flight, the technician is able to monitor both raw and reduced data in near real time. The software also includes graphics and plotting capabilities that allow the technician to review results during and at the end of each flight. Both raw and reduced data were stored on the hard disk in subdirectories identified by the flight name. All data files were copied to both primary and backup diskettes immediately after each flight.

VIZ Mark II Microsondes

The VIZ Mark II Microsondes are 10 x 19 x 15 cm and weigh 250 grams with a water-activated 18V battery. The radiosonde UHF transmitter sends its modulated signals in the 400 MHZ range. The Microsondes are calibrated at the factory in a computer-controlled environmental chamber. Calibration coefficients are stored in read-only-memory (ROM) within each sonde and are automatically transmitted to the receiver in 1.5 sec intervals. Temperature is measured using a rod thermistor, relative humidity using a carbon hygistor, and pressure using a capacitance aneroid capsule. Height is a derived parameter, calculated from the hydrostatic equation, using measured pressure, temperature, and humidity. The VIZ W-9000 is an automatic wind finding system that is based on tracking the sonde using the Loran-C navaid

network. The Microsonde incorporates a low-noise integrated circuit receiver tuned to the Loran-C frequency for reception from nearby Loran-C chains. Winds aloft are calculated from the change in balloon position (determined from navaid) with time. Equipment specifications are shown in **Table 2-3**.

Table 2-3. VIZ ZEEMET W-9000/ Mark II Rawinsonde Specifications

Measurement	Range	Accuracy	Resolution
Pressure	1080 to 3 mb	± 0.5 mb	0.1 mb
Temperature	-90 C to 60 C	± 0.2 C	0.1 C
Relative Humidity	5% to 100%	± 2.0%	1.0%
Wind Speed	0.5 ms ⁻¹ to unknown	± 0.5 ms ⁻¹	0.1 ms ⁻¹
Wind Direction	1 to 360	unknown	1.0

KZ-ECC Ozonesonde

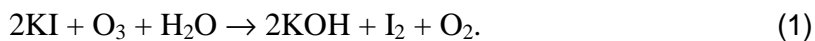
The EN-SCI Corporation KZ-ECC ozonesonde system was used in conjunction with the VIZ W-9000 Mark II Microsondes radiosonde package at both rawinsonde/ozonesonde sites.

The EN-SCI Corporation Model KZ-ECC atmospheric ozone sounding system is designed for ozone measurements from balloon platforms, with real-time data acquisition and processing. Ozone is measured with an electrochemical concentration cell (ECC) ozonesonde coupled through an electronic interface to a VIZ W-9000 Mark II radiosonde.

The ECC ozonesonde is of a simple design consisting of a rigid mainframe on which is mounted a motor-driven Teflon/glass air sampling pump, a thermistor for measuring pump temperature, an ozone sensing ECC, and an electronics box containing interface circuitry which couple the ozone sensor to the radiosonde. The mainframe is mounted in a lightweight weatherproof polystyrene flight box that is taped and wired to the radiosonde during flight.

The ozone-sensing cell is made of two bright platinum electrodes immersed in potassium iodide (KI) solutions of different concentrations contained in separate cathode and anode chambers. The chambers are linked with an ion bridge that, in addition to providing an ion pathway, retards mixing of the cathode and anode electrolytes thereby preserving their concentrations. The electrolytes also contain potassium bromide (KBr) and a buffer whose concentrations in each half-cell are the same. The driving electromotive force for the cell, of approximately 0.13 V, is provided by the difference in potassium iodide concentrations in the two half cells. Sample air is forced through the ECC sensor by means of a non-reactive pump fabricated from TFE Teflon impregnated with glass fibers. The pump is designed to operate without ozone-destroying lubricants. Pumping efficiency for each pump varies from pump to pump and is also dependent on ambient air pressure. The sampling flow rate is calibrated at the factory and checked in the field before launch. The ECC ozone concentration calibration is also determined prior to launch. Ozonesonde specifications are shown in **Table 2-4**.

When ozone in air enters the sensor, iodine is formed in the cathode half cell according to the relation



The cell converts the iodine to iodide according to



during which time two electrons flow in the cell's external circuit. Measurement of the electron flow (i.e., the cell current), together with the rate at which ozone enters the cell per unit time, enables ozone concentrations in the sampled air to be derived from

$$p_3 = 4.307 \times 10^{-3} (i_m - i_b) T_p t \quad (3)$$

where p_3 is the ozone partial pressure in nanobars, i_m is the measured sensor output current in microamperes, i_b is the sensor background current (i.e., the residual current emanating from the cell in the absence of ozone in the air) in microamperes, T_p is the pump temperature in kelvins, and t is the time in seconds taken by the sonde gas sampling pump to force 100 ml of air through the sensor.

Table 2-4. EN-SCI, KZ-ECC Ozonesonde Specifications

Parameter	Value
Instrument Size	7.6 x 7.9 x 13.3 cm
Flight Box	19.1 x 19.1 x 25.4 cm, weather proof polystyrene plastic
Total Weight	approximately 1,000 g, including batteries
Operating Temperature Range	40 C to -100 C
Operating Pressure Range	sea level to 2.5 mbs
Measurement Principle	coulometric, with an electrochemical concentration cell and a nonreactive Teflon gas sampling pump
Sensitivity	2-3 ppb by volume ozone in air
Response Time	15 seconds for 67% of change; 60 seconds for 85% of change
Noise	less than 1% of full scale
Estimated Measurement Uncertainty	less than $\pm 10\%$ of indicated value
Data Telemetry	instrument couples with interface circuitry and radiosonde, both provided by user

2.1.4 SODAR Systems

Two models of SODARS were utilized in the project. AeroVironment Model 2000 and Model 4000.

Model 4000 MiniSODAR System

Owing to space limitations at Dublin Canyon, The AeroVironment Model 4000 high-frequency Doppler SODAR system, or MiniSODAR was utilized. Instrument specifications are shown in **Table 2-5**. This system consists of a compact 32-element phased array antenna to form the three orthogonal beams needed to measure a complete three-dimensional wind profile. In addition to its compact size and minimal power requirements, winds are measured at 5-meter increments and are typically used as a wind tower replacement system. On the negative side, data is measured only up to 200 meters. However, this altitude was sufficient to measure the wind structure within Dublin Canyon.

A small shelter was constructed to house the acoustic signal processor and computer that functioned for both data logging and processing.

Table 2-5. AeroVironment Model 4000 MiniSODAR Specifications

Maximum Altitude: 200 meters
Minimum Altitude: 15 meters
Height Resolution: 5 meters
Transmit Frequency (approximate): 4500 Hz
Averaging Interval: 1 to 60 minutes (variable)
Wind Speed Range: 0 to 45 meters/second
Wind Speed Accuracy: < 0.5 meters/second
Wind Direction Accuracy: +/- 5 degrees
Weight: 255 lbs (116 kg)
Antenna Height: 4 ft (1.2 m)
Antenna Width: 4 ft (1.2 m)
Antenna Length: 5 ft (1.5 m)

Model 2000 SODAR System

At Livermore Airport and Sunol, AeroVironment Model 2000 SODAR systems were installed and operated. The Model 2000 design and operating specifications are presented in **Table 2-6**. This table presents the operational range for each component, the accuracy in comparison to an instrumented tower with sonic anemometers, the output resolution for the tabular wind and turbulence data, the sampling altitudes, the sampling height interval, the minimum sampling height, the transmit frequency and the averaging (reporting) interval. Each of these parameters is user selectable through the AeroVironment's proprietary software. The configuration shown in the table was used in CCOS.

The Model 2000 includes the following components: (1) the antenna array and pre-amplification electronics, (2) the acoustic signal processor (ASP) and (3) Pentium based computer user interface. The antenna array consists of three heated parabolic dishes enclosed with 1-2 meter high acoustic enclosures. Thnadners™ are mounted at the top of each enclosure. Thnadners™ are saw tooth (patented) acoustic devices that optimize the directional performance.

Three-dimensional wind profiles are determined measured using the data from all three antennae. One antenna is pointed vertically and the other two antennae are orthogonally oriented and positioned at variable zenith angles of up to 30° (nominally). In normal situations the non-vertical antennae are set to a zenith angle of 20°. For precise horizontal wind measurements in complex terrain locations the horizontal wind components are corrected for the actual vertical velocity on a pulse-by-pulse basis. Depending upon the physical characteristics of the operating site other operating zenith angles may be used.

The heart of the system is the acoustic signal processor (ASP) unit. It generates the acoustic pulses, tapers (to lengthen the diaphragm lifetime) the pulse, samples the received atmospheric echo at preselected height intervals, transforms these range gated data into the spectral domain, detects the mean frequency shift and translates these data into useful meteorological information.

The ASP is connected to a Pentium microcomputer via a serial communications link that normally operates at 19.2 Kbaud. The ASP produces three types of data: (1) the wind and wind turbulence information, (2) the time series of the echo intensity from the vertical antenna (called the facsimile data) and (3) troubleshooting information based on the real time examination of the Doppler spectra.

Table 2-6. AeroVironment Model 2000 SODAR Specifications

Measurement Range	
Horizontal Wind Speed Components	0 to \pm 60 m/s
Horizontal Wind Speed Vector	0 to 60 m/s (all quadrants)
Vertical Wind Speed Component	0 to \pm 25 m/s
Horizontal Wind Direction	0 to 359 deg.
Accuracy	
Horizontal Wind Speed Components	0.20 m/s for 2 m/s < WS < 5 m/s (5% for WS > 5 m/s)
Horizontal Wind Speed	0.30 m/s for 2 m/s < WS < 5 m/s (7% for WS > 5 m/s)
Vertical Wind Speed Component	0.10 m/s for W > 0.5 m/s (5% for W > 3 m/s)
Horizontal Wind Direction	3 deg. for WS > 2 m/s
Output Resolution	
Horizontal Wind Speed Components	0.01 m/s
Horizontal Wind Speed Vector	0.01 m/s
Vertical Wind Speed Component	0.01 m/s
Horizontal Wind Direction	1 deg.
Sampling Heights	20
Sampling Height Increment	30 meters
Minimum Sampling Height	20 meters
Transmit Frequency	500 to 6000 Hz.
Averaging and Reporting Interval	Single pulses to 1440 minutes
Wind Gust measurement	Moving average as selected by the user (single pulse or larger).

3. SITE OPERATIONS

3.1 Instrumentation and Station Design

The air quality monitoring stations operated by T&B Systems during the CCOS study were designed to supplement both Ozone (O₃) and Nitrogen Oxide (NO, NO_y) air quality measurements in and around the Livermore Valley during the summer of 2000. Additional Ozone instruments were placed at the Kregor Peak location, north of the Livermore Valley; at the Camp Parks location, in the Livermore Valley; and at the Lake Chabot location, west of the Valley. The Nitrogen Oxide instruments were placed at the Livermore/Rincon BAAQMD site and at the Lake Chabot site. An additional Nitrogen Oxides instrument was placed in a mobile van for operation by the BAAQMD.

The air quality monitoring sites, described in detail in of this report, were collocated with BAAQMD meteorological monitoring stations where possible. **Table 3-1** summarizes the instruments operated at each site.

Table 3-1. Air Quality Monitoring Instrumentation

Location	Operator	Ozone	Nitrogen Oxides	Meteorology
Camp Parks	T&B Systems	Teco Model 49 #10201	-----	-----
Kregor Peak	T&B Systems	Teco Model 49 #10192	-----	BAAQMD
Lake Chabot	T&B Systems	Teco Model 49 #10299	Teco Model 42cy #66902 - 354	BAAQMD
Livermore / Rincon	BAAQMD	BAAQMD Teco	Teco Model 42cy #66901 - 354	BAAQMD
Mobile	BAAQMD	BAAQMD Teco	Teco Model 42cy #66903 - 354	-----

Dashes indicate NOT required by monitoring plan.

The air quality instrumentation was supplied by the BAAQMD for the project. The NO_y instruments were purchased specifically for this project and arrived from the manufacturer and California Center for Research and Technology (C-CERT) on the day of installation. No acceptance tests were performed on the NO/NO_y instruments prior to installation. The ozone instruments were reconditioned BAAQMD instruments that were tested and audited by the BAAQMD prior to installation.

The air quality monitoring instruments were placed in air-conditioned shelters. Air quality samples were collected through Teflon manifolds. The characteristics of those manifolds are presented in **Table 3-2**. All manifolds started with inverted cones, to minimize dust intake, and were sleeved in either black plastic tubing or PVC pipe to minimize solar exposure. Sample intake lines for each instrument were separate and varied in length depending on site conditions. All samples for the ozone analyzers were pulled through the sampling lines and then through individual Teflon particulate filters prior to the monitoring instrument by the instrument's sampling pump. Air samples for the nitrogen oxides analyzers were pulled through two separate Teflon manifolds. The NO sample was pulled through a Teflon particulate filter followed by the sampling line, directly into the monitoring instrument. The NO_y sample was pulled first through a Teflon particulate filter, then an NO_x / NO_y converter, and finally through the Teflon intake manifold to the instrument. The instrument sampling-pump was used to pull both samples for the NO/NO_y instrument. All in-line filters were checked weekly and changed as necessary.

All data for T&B Systems was collected on Campbell Scientific data loggers, which provided 5-minute averaged and 1-hour averaged data. These data loggers were located at all sites, except Livermore.

Table 3-2. Sample Manifold Characteristics

Location	Manifold Design	Inlet (AGL)*	Inlet (Above Station)*	Sample Intake Length*
Camp Parks	1/4" OD Teflon Sleeved	Inverted Cone 15 feet (5.0 m)	Inverted Cone 3 feet (1.0 m)	15 feet (5.0 m)
Kregor Peak	1/4" OD Teflon Sleeved	Inverted Cone 9 feet (3.0 m)	Inverted Cone ---	21 feet (7.0 m)
Lake Chabot	1/4" OD Teflon Sleeved	Inverted Cone 18 feet (6.0 m)	Inverted Cone 6 feet (2.0 m)	15 feet (5.0 m)
Livermore (Rincon)	1/4" OD Teflon Sleeved	Inverted Cone 21 feet (7.0 m)	Inverted Cone 6 feet (2.0 m)	30 feet (10.0 m)

*All lengths and heights are approximated. Dashed line indicates unknown height.

3.2 Monitoring Operations

As mentioned above, the instruments were installed in the air quality stations as they arrived. Ozone monitoring instrumentation from the BAAQMD was made available first and installed as soon as the stations were available. The NO_y instruments arrived in late June and July and were installed as soon as was practical. The operational schedule of the instruments is presented below in **Table-3-3**.

Table 3-3. Site Operations

Location	Ozone Operation (Startup)*	Ozone Operation (Shutdown)*	NO _y Operation (Startup)*	NO _y Operation (Shutdown)*
Camp Parks	June 28, 2000	Sept. 28, 2000	-----	-----
Kregor Peak	June 15, 2000	October 03, 2000	-----	-----
Lake Chabot	June 21, 2000	Sept. 25, 2000	July 12, 2000	Sept. 27, 2000
Livermore/Rincon	-----	-----	July 08, 2000	Remains Operational

*Dates presented are those illustrating acquisition of actual valid data. Dashed line indicates NOT required by monitoring plan.

A physical inspection of the air quality monitoring stations occurred weekly, with more frequent visits as necessary. At each site visit, the physical condition of the sample manifolds, the status of the electrical connections, and the operation of each instrument were reviewed. When possible, T&B Systems downloaded data weekly through modem prior to the site visit, and more frequently during IOPs to assure that instrument operation was in order. Periodic data reviews occurred during the monitoring period to check for overall operational difficulties. During each site visit, specific instrument operational status parameters were recorded on log sheets. Overall site operations were recorded in the site log. Appendix A contains examples of Site Analyzer Inspection log sheets for each instrument.

The ozone analyzers were in operation during the period of early June through mid October

2000. The NO/NO_x analyzers were operational from the second week of July through mid October 2000. During that time period, all instruments were operational, except from June 30 to July 12 when the Ozone instrument at the Camp Parks site was inoperative. Other short periods of missing data occur because of calibrations, audits, or instrument power problems.

BAAQMD staff monitored the NO_y data generated at the BAAQMD Livermore Air Quality Station. The data are maintained and stored at the BAAQMD main offices in San Francisco. No data from this station is included with this report.

3.3 Instrument Characteristics

Both the Ozone and Nitrogen Oxide instruments were operated according to EPA standard operational guidelines. Flowrates and other operational parameters were maintained as closely as possible. Those instrument characteristics are summarized in **Table 3-4** below.

Table 3-4. Instrument Operational Characteristics

Instrument	Instrument Range	0 to 500 ppb
Ozone:	Sample Flow Rate	1.0 lpm
	Chamber Temperature*	0° C
	Chamber Pressure*	760 ton
Nitrogen Oxides:	Instrument Ranges	0 to 500 ppb
	Sample Flow Rates	1.2 lpm
	Chamber Temperature*	0° C
	Chamber Pressure*	760 ton

Data System - Recording Rate - 5-minute averages

*Internally calculated to reference T&P

As noted above, the instruments were operated at a standard temperature and pressure condition. The monitoring instruments maintained these conditions electronically. Thus, no corrections for these conditions were made to the data during data processing. The Ozone instrument at the Lake Chabot station did not have automatic temperature and pressure correction capabilities. Thus, the data from that site was normalized to the standard operating conditions using correction factors generated from calibration and audit data. Additional instrument operational parameters were recorded at each site visit (see site inspection sheet in Appendix A) and reviewed for consistency during the program.

3.4 Instrument Calibrations and Audits

During the 5-month operating period of the CCOS study, instrument calibration occurred on a regular basis using standardized calibration procedures. The Kregor Peak site calibrations were less frequent and limited by the accessibility of the station. Calibrations were performed by T&B System's staff. The calibration data was used to monitor operational consistency of each instrument at each site. Each parameter measured at each station was audited once during the program by an independent audit team. Absolute concentrations were referenced to audit data. Calibration and audit dates are listed on **Table 3-5**. Examples of calibration data forms for each instrument are included in Appendix A.

Ozone calibration was performed using a Dasibi Model 1008 Ozone Instrument and Calibration System. This calibration system was referenced to the BAAQMD monitoring network by audit on July 20, 2000. Nitrogen Oxide calibrations were performed using NO/NO_y internal instrument

dilution systems and NSTS referenced span gases obtained from Scott Marrin. No pre-study reference calibration occurred for the NO_y instruments.

Table 3-5. Instrument Calibration and Audit Dates

Camp Parks Ozone	Kregor Peak Ozone	Lake Chabot Ozone	Lake Chabot NO_y	Livermore NO_y
05/23/00	05/23/00	05/23/00		
08/09/00	08/10/00	08/09/00	08/08/00	08/03/00
			08/22/00	08/22/00
09/07/00		09/07/00	09/07/00	08/31/00
09/28/00	09/27/00	09/27/00	09/28/00	
10/02/00	10/10/00	10/06/00	10/06/00	
08/16/00 Audit	08/17/00 Audit	08/16/00 Audit	08/16/00 Audit	BAAQMD

3.5 Instrument Maintenance

During the CCOS study, each air quality monitoring station operated by T&B Systems was visited routinely by technical staff. Prior to the site visit, T&B staff reviewed weekly downloaded data files for instrument problems. Then during those site visits, routine preventive maintenance was performed on the measurement instruments. Manifolds were checked for dirt, leaks or other damage. Particulate filters were changed. Span gases and their support systems were checked for leaks or damage. And the instruments and data systems were checked for operational difficulties. Any difficulties observed during the site visit or during the pre-site visit data QC were resolved at that site visit. Only when the instrument had major operational problems was it removed from the site for repair. All site visit activity was recorded on the Field Data Logs for later reference.

3.6 Data Validation Procedures, Surface Air Quality Measurements

T&B Systems' responsibilities for the routine monitoring, data collection, and data validation extended to the Lake Chabot, Kregor Peak and Camp Parks sites. The operations and measurements at the BAAQMD Livermore/Rincon station and the sampling van are reported by the BAAQMD, and are not included herein.

3.6.1 Level 0 Data Validation Procedures

At the initiation of surface air quality monitoring activities, T&B Systems initiated a series of procedural steps to validate, edit, or delete air quality data collected at the CCOS sites during the months of June through September of 2000. The initial Level 0 data validation steps were as follows:

- a) The air quality data was collected and stored on-site data logger systems. The data collection was followed by real-time on-site processing by the data acquisition system to produce reduced 5-minute and 1-hour averaged air quality data (O₃, NO, and NO_y).
- b) The on-site data systems were interrogated periodically where possible by phone with all available data downloaded to T&B Systems.
- c) The on-site data collection modules periodically were collected and replaced. Each data

module was shipped to T&B Systems as a back-up for the telephone download. In several instances, Lake Chabot and Kregor Peak, telephone connections were intermittent, during which time most monitoring data was transferred with the data modules.

- d) Air quality monitoring data which was downloaded through modem or downloaded from the storage module was checked immediately for missing data, periodic spikes, or overall discrepancies in the expected pollutant concentrations. Potential problems were discussed with the site operator prior to any site visit to assure that any difficulties were reconciled.
- e) The air quality monitoring data from each site and parameter was displayed in time cross-section plots conducive to a quick comprehensive real-time review by experienced T&B staff.
- f) Data received from the on-site monitoring activities were collated and stored on the T&B Systems computer for later processing and/or validation. The original collated data files on the T&B System computer were considered the master data file (level 0) for the monitoring program. Any edits, alterations, or deletions to the data were made from copies of that file.
- g) Processing of the collected air quality data was initiated after the completion of the entire monitoring program. This initial processing (Level 0.5) involved removal of 5-minute averaged monitoring data for the instruments while inoperative or in calibration modes, as well as application of zero and/or span factors. Inoperative periods at this level of validation were identified for basic instrument non-operation or warm-up.

The procedures for this second phase of data processing were as follows:

- h) Data collected during periods when the instrument was inoperative were flagged in the data set. These periods were identified by the field personnel and noted on data validation forms. Each period was identified and reasons for the invalidation were noted (flagged as EQP). **Appendix A** contains an example of these data validation forms.
- i) During the monitoring period, each air quality instrument was calibrated, zeroed and/or audited on a frequent basis. The procedures used are described in Section 3.4 of this report. During the periods when these activities were in progress, actual air quality monitoring data could not be collected. Again, using field notes, the operator identified each of these periods, and noted them as inoperative of data validation forms (flagged as CAL).
- j) Application of a zero or calibration factor to the monitoring data was performed on the data subsequent to steps g, h, and i above. A basic rule was used when applying these factors. Departures of less than 5 percent for the instrument calibration were not considered significant and instrument data within that criterion was not corrected.
- k) Instrument “zeroes” for filtered clean air were measured during each calibration. In addition, electronic instrument “zeroes” were obtained during each calibration and whenever feasible during other site visits. This electronic “zero” represented the instrument offset as compared to a reference 0 ppb concentration and was caused by instrument drift. As a result, a zero correction was applied to all monitoring data such

that the lowest measured pollutant concentration at a given site as measured by the reference calibration system was defined as 0 ppb. All pollutant concentrations were referenced to that lowest point. Since instrument electronic “zero” changes could occur during periods of instrument non-operation or calibration, each distinct period of continuous instrument operation or group of independent periods was treated independently for instrument “zero” drift.

- l) Calibration corrections were applied to logical periods of instrument operation as appropriate. A more thorough discussion of calibration factors is presented in Section 3.6.4 below.
- m) The appropriate data validation flags were inserted into the database producing a Level 0.5 data set. Level 0.5 data was displayed on time cross-sections for final review.

3.6.2 Application of Calibration Correction Factors (Level 0.5)

The application of correction factors to the CCOS air quality monitoring data was performed after all monitoring, calibration, and auditing data were available. As mentioned above, the data were broken into numerous periods of continuous operation separated and identified by unique calibration factors. Both zero corrections and calibration corrections were applied to the data in this way. See Appendix A for calibration summaries. Although zero measurements and calibrations occurred frequently, longer periods of consistent operation and small variations in the instrument zero and calibration factor were combined for data processing. Both the instrument zero and calibration factor were used to monitor instrument operating consistency. Large changes in either factor were indicative of a major instrument problem and were used to isolate periods of poor data quality from those of high data quality. Tables 3-6 and 3-7 summarize the results of both the zero and calibration activities during the CCOS monitoring period. Instruments and sites are identified in the table.

Table 3-6 summarizes the zero and calibration data for each ozone monitoring station. Instrument offsets were consistently at 0 ppb such that no “zero” offset corrections were applied to the ozone data at Level 0.5 validation. Calibration factors were consistently near 1.0 (+/- 2%) at the Camp Parks and Kregor Peak sites. The ozone instrument at the Lake Chabot site, however, exhibited calibration factors in excess of 1.1 consistently throughout the monitoring program. This calibration slope was caused by the fact that the ozone instrument at Lake Chabot had no internal temperature or pressure correction (as was the case with all other instruments). As a result, all ozone data from the Lake Chabot site had to be corrected for rough temperature and pressure differences using calibration data. The elevation of the Lake Chabot station was such that temperature and pressure corrections were normally in excess of 10 percent. This produced combined temperature and pressure “calibration factors” of 1.1 and greater.

As indicated in Section 3.4 of this report (Table 3-5), calibrations occurred as often as eight times for each ozone-monitoring instrument. Data from these calibrations indicated that the instruments were operating relatively consistently during the 4-month operating period. Large variations were apparent in neither the calibration “slope” nor the calibration “zero”. As a result, several distinct operating periods were combined producing calibration and zero data for a few groups of operating periods. The data presented in Table 3-6 are for those groups or operating periods

Table 3-6. Ozone Instrument - Zero and Calibration Factors

Kregor Peak			Camp Parks			Lake Chabot		
Period of Operation	Zero	Calib.	Period of Operation	Zero	Calib.	Period of Operation	Zero	Calib.
6/15 - 8/25	0.000	0.99	6/29 - 7/02	0.000	0.98	6/21 - 8/16	0.000	2.01
8/25 -10/10	0.000	0.99	7/12 - 9/13	0.000	0.98	8/16 - 9/13	0.000	1.13
			9/13 -10/02	0.000	0.97	9/13 -10/06	0.000	1.31

Table 3-7 summarizes the zero and calibration data for both the NO and NO_y instruments at the Lake Chabot site. Since the Lake Chabot site had an instrument with an internal calibration system, calibration factors were nominally set at the beginning of the program. However, the instruments remained stable during the duration of the monitoring program such that the calibration factors for the entire program were the same. Note that the BAAQMD assumed the responsibility for calibration and data validation for Livermore/Rincon and the monitoring van. Accordingly, this information will be reported by the BAAQMD rather than here.

Table 3-7. Nitrogen Oxide (NO/NO_y) Instrument - Zero and Calibration Factors

Period of Operation	Lake Chabot NO Zero	Lake Chabot NO Calibration
7/12 -10/12	0.000	1.000

Period of Operation	Lake Chabot NO _y Zero	Lake Chabot NO _y Calibration
7/12 -10/12	0.000	1.000

3.6.3 Incorporation of Air Quality Audit Data

As indicated on Table 3-5, each surface air quality monitoring station and instrument was audited once during the CCOS monitoring period. These audits were performed on August 14 and 15 by representatives of Parsons, Inc. The audit data was used to compare internal calibration data with an independent set of reference instruments and standards in order to determine the accuracy of both the air quality monitoring instruments used for this program and the instruments used by T&B Systems for calibration. Since ozone instruments were referenced to a Dasibi Transfer Standard (and to a BAAQMD reference instrument), it was expected that instrument ozone calibration and audit data would be quite similar. Any differences between audit and calibration factors were attributed to instrument problems. All such problems were investigated at the time of each audit to determine the source or sources of any discrepancy. In this way a combined calibration factor/audit factor could be obtained for each instrument for the entire monitoring program. Thus, if a problem were found during the audit, two audit factors would be generated; one for the initial uncorrected instrument (set-up to audit), and one for the instrument in a modified corrected configuration (audit to tear-down). In this way, air quality data passing through Level 0.5 could be considered accurate and need not be adjusted to reflect audit data. **Table 3-8** presents both initial and final audit factors for all instruments used during CCOS.

Table 3-8. Audit Factors

Audit Factor / Station	Zero Offset	Audit Factor	Audit Factor Final
Kregor Peak Ozone	- 0.000	1.026	1.026
Camp Parks Ozone	+ 0.003	.016	1.016
Lake Chabot Ozone	- 0.001	2.01*	1.25
Lake Chabot NO	- 0.000	1.493**	1.10
Lake Chabot NO _y	- 0.000	1.493**	1.11

*Two filters in-line, reduced optical chamber concentration.

**Using incorrect station calibrator flow rate.

As a result of the audits, several problems were found with the Lake Chabot Station instruments. Both the Ozone and Nitrogen Oxides instruments initially were found to measure pollutant concentrations quite differently from those generated for the audit. Once these problems were diagnosed and monitoring system changes made, the final audit results were quite good.

In the case of Ozone measurements, Kregor Peak and Camp Parks audits indicated in-place measurements were within acceptable limits (+/-5 percent) and no correction factors need be applied to the data. Lake Chabot data, on the other hand, exhibited problems. As discussed above, the ozone instrument located at the Lake Chabot site did not make internal corrections for temperature and pressure. Thus, at the altitude and temperature of the station, corrections of 10 to 20 percent were expected. In addition, the particulate filter on the instrument in-line pre-filter mistakenly contained two Teflon filters rather than one. A second filter had unknowingly been placed incorrectly into the housing prior to use in this field study. This created a greater than desired vacuum in the optical chamber of the instrument, which in turn resulted in a lowered measured ambient concentration of ozone. Thus, the initial correction factor for the Lake Chabot ozone instrument (set-up to audit) was 2.01 was incorrect. After the second filter was removed and the correct vacuum was achieved in the optical chamber, the calibration correction (factor) was reduced to that necessary to compensate only for the temperature and pressure corrections. Lake Chabot Ozone data obtained prior to the audit was subsequently corrected for temperature, pressure, and the vacuum problem. Lake Chabot Ozone data obtained after the audit was corrected for temperature and pressure only.

During the independent audit of the NO/NO_y instrument at the Lake Chabot site, a large discrepancy was measured between the audit measured NO/NO_y concentrations and the station measured NO/NO_y. This discrepancy was related to errors in the calibration of the Teco Model 146C calibration instrument's internal flow meters. The internal total flow meter indicated 800 cc/min when only 600 cc/min was actually flowing from the calibrator. Due of the late delivery date of the NO/NO_y instruments and the multigas calibration systems from C-CERT, a rigorous BAAQMD audit/check of the calibration system was not possible. The calibration instrument was installed at the Lake Chabot Station "as is" and assumed to be in operating order. No change was made to the mass flow meter in the instrument during the time period in which the instrument was operated at the Lake Chabot Site. Thus, the calibration of the monitoring instrument did not change, and the audit correction factor calculated at the time of the audit was used to correct all NO and NO_y monitoring data for the site.

3.6.4 Final Validated Calibration/Audit Correction Factors

In order to facilitate overall data processing of the air quality data obtained by T&B Systems during the CCOS Study, a combination calibration factor / audit factor was used. In essence, this combined factor corrected all the data for temperature and pressure (where necessary), for variations in weekly calibrations, for audit observations, and for any instrument or calibrator problems encountered during the program. All such factors, discussed above, were combined into one “combined” factor for data processing. The resulting factors are presented in **Table 3-9** Ozone and **Table 3-10** NO/NO_y.

Table 3-9. Ozone Instrument - Final Zero and Correction Factors

Kregor Peak			Camp Parks			Lake Chabot		
Period of Operation	Zero	Calib.	Period of Operation	Zero	Calib.	Period of Operation	Zero	Calib.
6/15 - 8/25	0.000	1.025	6/29 - 7/02	0.000	1.000	6/21 - 8/16	0.000	2.01
8/25 - 10/10	0.000	1.018	7/12 - 9/13	0.000	0.993	8/16 - 9/13	0.000	1.130
			9/13 - 10/02	0.000	0.989	9/13 - 10/06	0.000	1.310

Table 3-10. Nitrogen Oxide (NO/NO_y) Instrument - Zero and Calibration Factors

Period of Operation	Lake Chabot NO Zero	Lake Chabot NO Calibration
7/12 - 10/12	0.000	1.425

Period of Operation	Lake Chabot NO _y Zero	Lake Chabot NO _y Calibration
7/12 - 10/12	0.000	1.438

3.7 Monitoring Difficulties

As is the case in most short-term field monitoring programs, problems due to siting, communication or equipment occurred. Fortunately, those encountered during CCOS did not result in any serious data losses or budget overruns. The more significant difficulties that occurred are discussed in this section.

3.7.1 Data Acquisition Problems

There were frequent problems associated with the data collection process during the CCOS monitoring period. First, the sites were remote and telephone connections were occasionally disrupted. During those periods instrumentation problems went undetected until either communications were restored or the site was visited. As a result, some data was lost for periods of time. Fortunately, data loss was kept to a minimum.

The second type of data problem occurred with the air quality monitoring instrument's “zero” and “zero drift”. Since the database collected at the T&B office was 5-minute averages, it was felt that concentrations less than 0 ppb for ozone, NO, or NO_y were not reasonable. Any measured concentration of less than 0 ppb was considered noise resulting from either the monitoring instrument or the data logger. Thus, in the data processing, each parameter was adjusted for noise by assuming that the lowest measure concentration of any species was to be considered

“0” ppb. All other measurements were positive of that “zero” measured value. As discussed above, data for each distinct period of operation or groups of these periods was corrected separately from all others.

3.7.2 Site Data Problems

Each air quality monitoring station had its own set of data anomalies. Those can be summarized as follows:

Kregor Peak Ozone - The monitoring station was subject to a periodic power fluctuation or interference problem. This problem occurred regularly at approximately 13:15 PST on the same day, every week. The result was a large data spike that was inconsistent with normal ozone measurements. The spike occurred during one or two consecutive five-minute intervals. Each of these data spikes was flagged “EQP” designating potential instrument problems and deleted from the resulting hourly-averaged data calculation. Fourteen such data spikes were observed.

Lake Chabot NO/NO_y - The monitoring station is located within an East Bay Park District Maintenance Office trailer. During the day, large diesel and non-diesel powered trucks parked next to the office for varying periods of time (5 to 20 minutes). NO emissions from those vehicles moved rapidly to the monitoring instrument’s sample manifold, resulting in large NO and NO_y spikes. These spikes represent real pollutant concentrations and are left in the database. They are used in all 1-hour averaged data.

There was, however, a problem with the observed data resulting from the differences between the sampling times for the NO and the NO_y channels of the instrument. For the NO/NO_y instrument, both the NO and NO_y channels were calibrated simultaneously. Both had the same sample flow rate and both passed through the same length of sample manifold (different pieces) and sample intake particulate filter. The NO_y channel, however, passed through an additional NO_y – NO/NO_x converter located at the sample manifold intake. This additional volume on the NO_y channel resulted in a spreading of the NO_y peak and a NO_y sample lag time increase in relation to the NO peak. Thus, when short-duration NO/NO_y peaks are measured, the NO peak precedes the NO_y peak for the same plume. Under these conditions, the concentration of NO can exceed that of NO_y for a given 5-minute. The NO concentration in the succeeding 5-minute-interval was correspondingly low. When this occurred, the data was flagged “SUS”. This indicated that the NO and NO_y concentrations measured during any one 5-minute interval, plus any single 5-minute record immediately prior to or following this record should not be compared without additional consideration.

4. OZONESONDE MEASUREMENTS

During CCOS, T&B Systems made measurements of ozone and meteorology aloft using ozonesondes. Meteorological parameters measured were ambient temperature, relative humidity, and winds as a function of pressure-height. A description of the equipment and specifications are provided in Section 2. Measurements were made from Granite Bay (east of Sacramento) and Parlier (southeast of Fresno). Both sites are downwind of major metropolitan areas and were selected to provide information on the vertical distribution of ozone within the aged urban plume. Both locations were also CCOS Research Sites at which a comprehensive suite of ambient air chemistry measurements was made as well.

4.1 Ozonesonde Operations

Upon the issuance of a forecasted IOP event, the lengthy ozonesonde preparation procedure commenced at the T&B Systems' field office in Visalia. Initial preparation consisted of conditioning the ozonesonde to high ozone levels for several hours, charging the electrochemical cells, and running standard tests to ensure operation. The standard procedures used are included in Appendix A of this report. The conditioned and checked sondes were shuttled to the sites at Parlier and Granite Bay at the initiation of and during IOPs. Final preparation steps and assembly with radiosonde and interface were conducted on-site immediately prior to sonde release.

Final preparation included comparing surface ambient ozone, temperature, and relative humidity with the station ground-based instrument readings. If readings were significantly different, the ozonesonde and/or radiosonde were rejected and another prepared. At the Granite Bay site a sampling line with pump was installed adjacent to the inlet to the station ozone analyzer manifold sampling line. Thus, surface ozone readings were collocated and expected to compare closely. The ozonesonde and station ozone analyzer at Parlier were nearby but not collocated. As a consequence, the standard for significant (ozone) differences varied between the sites. At Granite Bay, ground truth levels were expected to be within 10 ppb. At Parlier, levels were expected to be within 20 ppb.

Ozonesonde/radiosonde packages were attached to helium-filled balloons (and parachutes) using nylon line. Balloons and instrument package were released as close to scheduled times as possible. Soundings were tracked to approximately 500 mb (~18,000 ft.) A sounding not reaching 850 mb (~5,000 ft.) was repeated. The schedule of soundings was determined for each episode by the CCOS Project Manager and T&B Systems Project Manager, and was not necessarily the same at both sites. The release schedule is shown in **Table 4-1**. A total of 115 successful soundings were made—54 from Parlier and 61 from Granite Bay. For each sounding, the maximum altitude ozone, pressure, temperature and humidity data, and the maximum altitude of wind data captured are included. All but two soundings reached the target altitude of 500 mb.

Ozone, pressure, temperature and humidity (PTU) data were transmitted to the W-9000 ground receiver every 1.2 seconds. Sonde space-coordinates (Loran-based) were transmitted approximately every 7 seconds. Real-time processing algorithms smoothed the space-coordinates and provided winds averaged through 15-second layers. The balloon ascension rate was nominally 200 meters per minute, which resulted in ozone and PTU data every 4 meters and winds every 50 meters. Site logs were maintained that documented site conditions, problems encountered, and weather observations.

Table 4-1. Ozonesonde Soundings CCOS 2000

July Soundings - CCOS Ozonesonde**Parlier**

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
7/23	6539/7439	NS	6431/6304	NS	6417/6308	6453/6307
7/24	6415/6276	NS	6425/6308	NS	6417/6280	NS
7/30	6355/6222	NS	3146/3004	NS	6372/6241	6087/5933
7/31	6348/6216	6355/6185	6998/6313	4234/604	6296/6155	6226/6068

Granite Bay

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
7/23	5930/5802	NS	6023/5918	NS	00/00	5977/5837
7/24	6000/5843	NS	6068/5920	NS	1874/3093	NS
7/30	6021/5790	NS	6154/5984	NS	6139/5941	6136/5941
7/31	6142/5997	NS	6186/6022	NS	6250/6083	6179/5991

August Soundings - CCOS Ozonesonde**Parlier**

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
8/1	6449/6171	NS	6341/6201	6354/6223	6370/6103	NS
8/2	NS	6631/6575	NS	6422/6276	NS	NS
8/14	6285/6110	NS	6440/6265	6563/6426	6299/6122	NS

Granite Bay

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
8/1	6221/6037	NS	6215/5998	NS	6276/6044	NS
8/2	NS	4822/4809	NS	6176/5998	NS	NS
8/14	6263/6120	NS	6251/5940	6132/5974	6144/6001	NS

September-October Soundings - CCOS Ozonesonde**Parlier**

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
9/14	NS	6270/6117	6291/6143	6307/6112	NS	NS
9/17	6300/6164	NS	6322/6180	6321/6173	2561/6134	6303/6140
9/18	6300/6146	NS	6347/6173	6347/6181	6322/6173	6351/6144
9/19	6511/6319	NS	6350/6175	6371/6217	6342/6177	6322/6159
9/20	6388/6236	NS	5240/6598	6272/6127	6291/6113	6233/6063
9/21	6235/6232	NS	6186/6020	6185/6008	6206/6048	NS
9/30	NS	NS	NS	NS	NS	NS
10/01	NS	NS	NS	NS	NS	NS
10/02	NS	NS	NS	NS	NS	NS

Granite Bay

Date	05 PDT	08 PDT	11 PDT	14 PDT	17 PDT	22 PDT
9/14	NS	6152/5952	NS	6085/5875	NS	NS
9/17	6026/5849	NS	6064/5907	6171/6015	5992/5863	6036/5867
9/18	3567/3558	NS	6187/6077	6219/6047	6186/6019	6209/6007
9/19	6183/6018	NS	6206/6005	6186/6022	6140/5919	6140/5919
9/20	6084/5879	NS	6087/5993	6112/5932	6084/5884	0/0
9/21	6056/5882	NS	6008/5826	6021/5869	5945/5762	NS
9/30	5955/5797	NS	6128/5924	6124/5955	5931/5701	NS
10/01	5943/5748	NS	3025/2827	5918/5757	5915/5771	NS
10/02	5873/5710	NS	6032/5814	5871/5690	5848/5642	NS

Table entries are maximum height (meters) of soundings -- PTUO3/winds. NS = None scheduled.
On 9/14 scheduled sounding times were actually 08, 12, and 15 PDT.

4.2 Quality Assurance

Standard operating procedures were followed that included checksheets and pre-sounding information, both for initial and final sonde conditioning and checkout. The standard forms are shown in **Appendix A**.

Ground-level comparisons between the sonde ozone readings and station analyzer were made prior to each launch whenever possible. There were some occasions when the station analyzer readings at Parlier were not available. If the difference between the readings were not within specified tolerances—10 ppb at Granite Bay and 20 ppb at Parlier--the sonde was rejected. The sonde-station measurement comparisons are summarized in **Figure 4-1**. On the figure, the readings are plotted and a best-linear fit curve shown. The slope and intercept of the best-fit curve is given along with various statistical measures associated with the regression. This information is summarized in **Table 4-2**.

Table 4-2. Regression Results Comparing Sonde and Ground-Truth Ozone Reading

	Slope	Intercept	R²
Granite Bay	0.98	-2.5	0.99
Parlier	0.89	-8.0	0.91

As can be seen the slope of the best linear-fit was within 2 percent of unity at Granite Bay and 11 percent of unity at Parlier. Generally, ozonesondes measured less ozone than the station analyzer. As mentioned earlier, at Granite Bay the sonde and station analyzer were essentially collocated whereas at Parlier the sonde inlet was generally lower (1 versus 4 meters) than the inlet to the station sampling line and several yards distant.

Station ambient temperature, relative humidity, wind direction and wind speed were recorded at release time and compared to sonde values. Typically bias or faulty sensors are identified in this manner prior to balloon release. This "ground truth" reading provides confirmation that the sensors were correctly functioning in the event readings aloft are questioned during analyses.

During post-processing and data validation, an experienced air quality scientist reviewed each sounding. Each measured and computed parameters (height and dew point) were plotted and examined for internal consistency (temperature lapse rates, balloon ascension rates, data spikes, etc. Time-height cross-sections of ozone and winds were developed. Isopleths of ozone were objectively drawn and examined for outliers and unusual characteristics.

4.3 Problems Encountered

As evidenced by the high data capture rate, no significant problems were encountered. The only shortcoming in the monitoring plan was the unavailability of collocated surface ozone measurements at Parlier for ground "truth". Although an analyzer was within 50 meters, the measurements were not collocated and exhibited differences. It would have been most desirable to have a ground truth system similar to Granite Bay to reduce the uncertainty in the measurement.

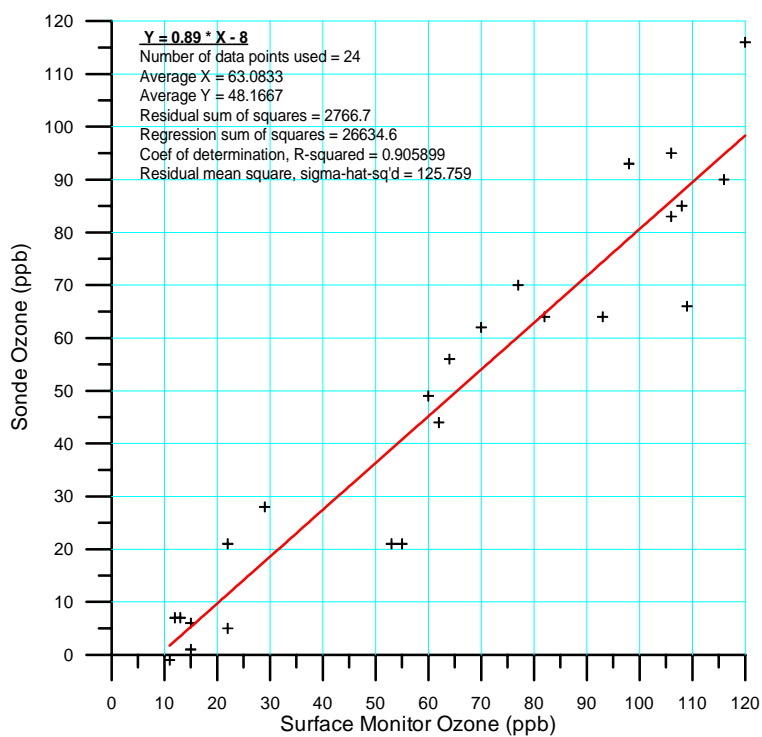
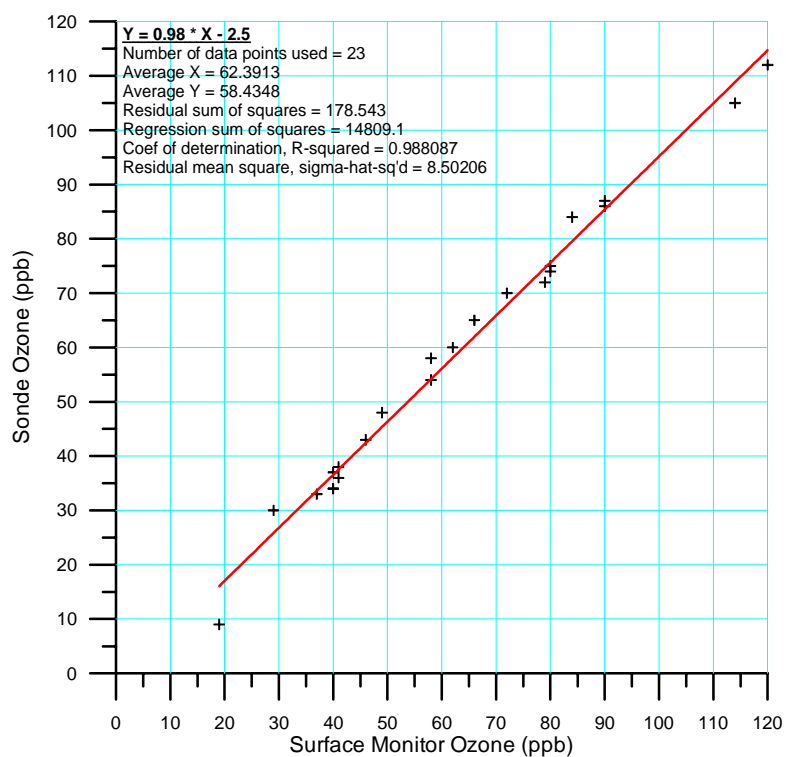


Figure 4-1. Comparison Between Surface Ozone sonde and Station Analyzer Ozone Levels at Granite Bay (top) and Parlier (bottom) CCOS 2000

5. DOPPLER ACOUSTIC SOUNDINGS SYSTEM OPERATIONS

Doppler Acoustic Soundings systems, usually referred to as SODAR (for Sound Detection and Ranging) were operated at three sites during CCOS. AV Model 2000 systems were utilized at Livermore Airport and Sunol, and an AV Model 4000 system at Dublin Canyon (refer to Section 2). The major differences between the two SODAR models are resolution and maximum height. The Model 2000 is capable of reaching 600 meters above the ground level and the winds are resolved to 30-meter layer averages. The Model 4000 System only measures to 200-meters but provides 5-meter layer data. Although data monitoring was continuous, only measurements during IOP's were validated and submitted to the CCOS integrated database.

The SODARS were earmarked for operations in the Livermore Valley and adjacent passes. BAAQMD and T&B Systems' staff conducted numerous site surveys but had difficulty finding sites that were capable of measuring representative winds because of ambient noise and urban development. Compounding the problem, potential sites that were acoustically quiet with access and commercial power were adjacent to businesses and/or residences that would be adversely impacted by the SODAR signal.

Sodar operations were established initially at the CCOS Research site at Sunol, the CRPAQS Dublin Canyon site, and near the BAAQMD meteorological site at Lake Chabot. It was necessary to relocate the Lake Chabot system to the Livermore Airport owing to noise complaints from the adjacent neighborhood. The Dublin Canyon SODAR was collocated with CRPAQS equipment approximately halfway up the south side of the canyon. Owing to the available space, the Model 4000 system, which has a much smaller footprint, was installed there rather than the larger Model 2000 thus reducing the vertical extent of measurements. Nevertheless, this system was capable of measuring winds to at least the top of the canyon.

Both Sunol and Dublin Canyon were generally noisier than desired due to automobile traffic and air conditioning noise (at Sunol) but no alternative sites that offered better conditions were available. Light air traffic was the only interference at the Livermore site and it was negligible.

5.1 SODAR Operations

The Lake Chabot and Sunol SODARS actively began monitoring on July 7 and July 9, respectively. The East Bay Regional Parks received a number of noise complaints regarding the Lake Chabot unit almost immediately. The unit was taken off line on July 12 after several attempts at reducing the amplifier power and redirecting the antennas. It was moved to the Livermore Airport on July 14 after arrangements were made with airport officials.

Telephone communications were established with the Sunol and Livermore Airport SODAR data systems. Cellular communications could not be established at Dublin Canyon. The sites with communications were interrogated routinely (at least twice weekly and prior to the start of each IOP) to check the status of the equipment. If problems were noted, a technician was dispatched promptly to the site. Data were downloaded to diskettes weekly and at the completion of each IOP.

A number of local Sunol residents called the local CDF and Water District offices regarding the SODAR there. With one notable exception, residents expressed more alarm at the unfamiliar sound than annoyance. Nevertheless, the unit at Sunol was turned off on June 14 pending an investigation of the remaining complaint. At the suggestion of Sunol locals, BAAQMD personnel posted a bulletin in the Sunol Post Office describing the measurements and their purpose. The

SODAR was turned back on June 26. One very strongly voiced complaint was received after the SODAR was returned to operation. After discussions with ARB and BAAQMD, it was decided to turn the SODAR off until further notice. Attempts to remedy the situation by amplifier power reduction and redirecting the antennas failed, and the complaint continued. Another remediation attempt was to broker an agreement to only operate during IOPs was rejected. As a consequence, the unit only operated between 07 and 19 PST. During the siting and installation tasks, ambient noise levels were low and ambient temperatures were relatively cool. It was not until temperatures increased that interference noise from a nearby air conditioner was noticeable. It was discovered during the audit that the air conditioner noise was dominating the wind measurement rendering much of the data unusable. The winds appeared reasonable at first glance but were unreasonably consistent. Building an acoustic fence around the interfering air-conditioner mitigated this problem.

The Dublin Canyon measurements generally were very reliable below about 150 meters. An echo from the surrounding terrain sometimes interfered with the wind signal. This phenomenon was detectable as an inflection point in the vertical wind speed profile. Cellular communications with the site's data system was never established. Weekly and pre-IOP site visits proved adequate to provide a high data-capture rate.

The Livermore SODAR performed flawlessly. A data loss occurred with a site power outage from flooding due to a faulty irrigation pump. This problem was corrected soon after discovery during a routine site visit.

A summary of operations is provided in **Table 5-1**.

Table 5-1. SODAR Operational Summary – CCOS 2000

Milestone	Sunol	Livermore AP	Dublin Canyon	Lake Chabot
Start of Monitoring	June 9	July 14	July 15	June 7
Inop due to complaints	June 14-26			
Inop due to complaints	July 1-12			
Operated only during day	July 12-Oct 1			
Site Audit	August 18	August 17	August 19	
Noise Control Structure Built	August 25			
End of monitoring	October 1	October 1	October 1	June 12

5.2 Data Validation

Profiler Analysis and Display Software (PADS), provided to T&B Systems by Aerovironment was used to provide text and graphical analysis for quality assurance. PADS was interfaced with our PC-based computers. This program provided an effective editing and analysis tool for the SODAR wind data. PADS enabled us to screen the Level 0.5 data before it was viewed as a graphical or text output. This greatly reduced quality control analysis time by filtering out noisy data that did not meet pre-qualified criteria.

PADS graphical output allowed the data reviewer to view time height cross section wind profiles, wind roses, data recovery rate plots, Sigma W plots and mixing level heights. The text output allowed for the viewing of daily wind table reports, monthly data reports, and finally export data from standard files creating an ASCII file with pre-selected information.

An example of the Time Height Cross Section (THC) of hourly averaged wind profiles that was used for data evaluation is shown in **Figure 5-1**. THCs were used by T&B Systems meteorologists to screen outliers using defined data parameters.

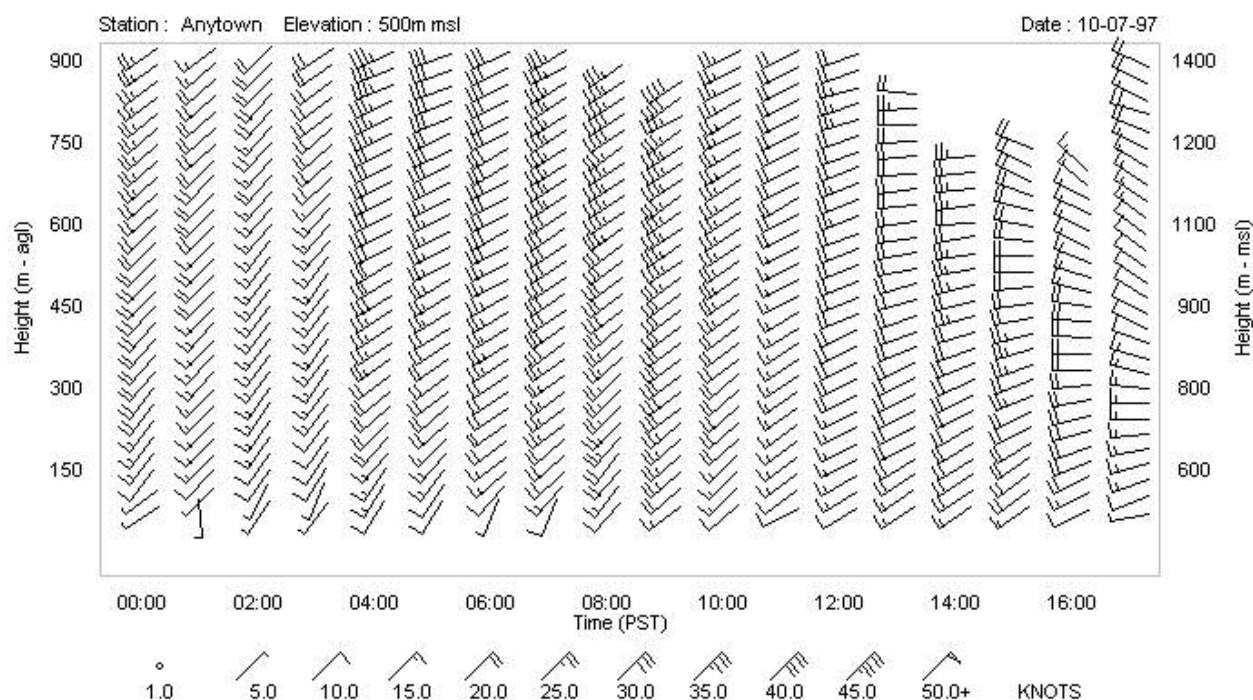


Figure 5-1. Example of Screening Process for SODAR Data Validation
(Source: AeroVironment)

An interactive editing program developed by T&B Systems was then used for data validation. The editing program enabled editing flags to be assigned to individual records or blocks of records. The editing flags were specific to the CCOS database specifications. An experienced meteorologist who also was the primary sodar operator during the field study reviewed the data. Time-height cross-sections of 15-minute averaged wind speed and direction were plotted, along with the number of consensus points that were comprised the calculations. Examination of the plots typically revealed outliers--extreme wind shears both temporary and vertically. Suspect wind levels were further evaluated by examining the signal strength, number of consensus points, etc. It was left to the discretion of the reviewer as to whether datum was suspect or invalid. Audit results (discussed below) uncovered systematic errors both at Sunol and Dublin. Records affected were flagged as invalid.

To date only measurements during two IOPs have been validated and submitted to the CCOS Data Manager. The dates for which validated data are available are shown in **Table 5-2**. The data were submitted as 15-minute consensus volume-averaged wind direction and speed levels. The vertical resolution (bin) of the winds is 5-meters for Dublin Canyon, and 30-meters for Sunol and Livermore Airport.

Table 5-2. Periods Included in the Validated SODAR Database

Date	Sunol	Livermore AP	Dublin Canyon
7/19	√	√	√
7/20	√	√	√
7/21	√	√	√
7/22	√	√	√
7/23	√	√	√
7/24	√	√	√
7/25	√	√	√
7/26	√	√	√
7/27	√	√	√
7/28	√	√	√
7/29	√	√	√
7/30	√	√	√
7/31	√	√	√
8/1	√	√	√
8/2	√	√	√
9/16	√	√	√
9/17	√	√	√
9/18	√	√	√
9/19	√	√	√
9/20	√	√	√
9/21	√	√	√

5.3 Independent Audit Results

Sunol - The audit revealed that the data was being compromised by a nearby air conditioner that had been inactive during the initial site survey and installation. Compounding the problem was that the contaminated wind speed and direction were at first glance reasonable considering the location and regional meteorology. The local terrain would be expected to steer the wind in a persistent manner from west to east. To remedy this situation, an acoustic "fence" was built to shield the SODAR from noise emitted by the air conditioner. This action improved the measurements significantly.

The sodar transmit pulse was turned off each night to appease neighbors who were annoyed by its operation. However, the SODAR continued operating in a "listen only" mode. This provided a good opportunity to evaluate the background noise. A review of the previously collected data during the audit showed some serious noise contamination where the sodar interpreted valid winds without a transmit pulse. This noise was shown by equal components (N/S and E/W) and consistent speeds at about 10 m/s at 225 degrees. Unfortunately this was also the prevailing wind direction quadrant, which is the likely reason the erroneous winds were not detected

earlier. An examination of the ambient noise spectrum confirmed that the suspect air conditioner operated at about the frequency that would produce such an effect. Moreover, a review of past data during a period when the station air conditioner was known to be non-functional showed a considerable reduction in the active noise interference with winds appearing to reflect the appropriate atmospheric echoes. With the air conditioner running it appeared that data may only be useable up to a couple hundred meters.

The only other auditor note of consequence was that the data was not vertical-velocity corrected by the manufacturers processing software. It was recommended that measured vertical velocities be reviewed, and then determine if post processing to account for the vertical motion is warranted.

The data were carefully reviewed during data validation and much of the data were flagged as invalid or suspect, particularly at heights above 200 meters. The horizontal winds were not corrected for vertical motion. This option may be exercised during Level 2 validation.

Livermore Airport - No problems were found during the audit that would compromise the data.

Dublin Canyon - The audit revealed that there were significant reflections from the cell towers and trees on the hillside. The reflections were present between about 70 and 100 meters, inclusive, and seemed to affect primarily the U component. The result of the reflections was a biasing of winds toward zero in this component. This, in turn, affected the calculated resultant wind speeds and directions in that range. No other issues that significantly affect the data were observed.

Figure 5-2 shows the effect of the reflections on the data. Since this is caused by a physical characteristic of the site, it was not possible to correct the data. The data were flagged as invalid during data validation.

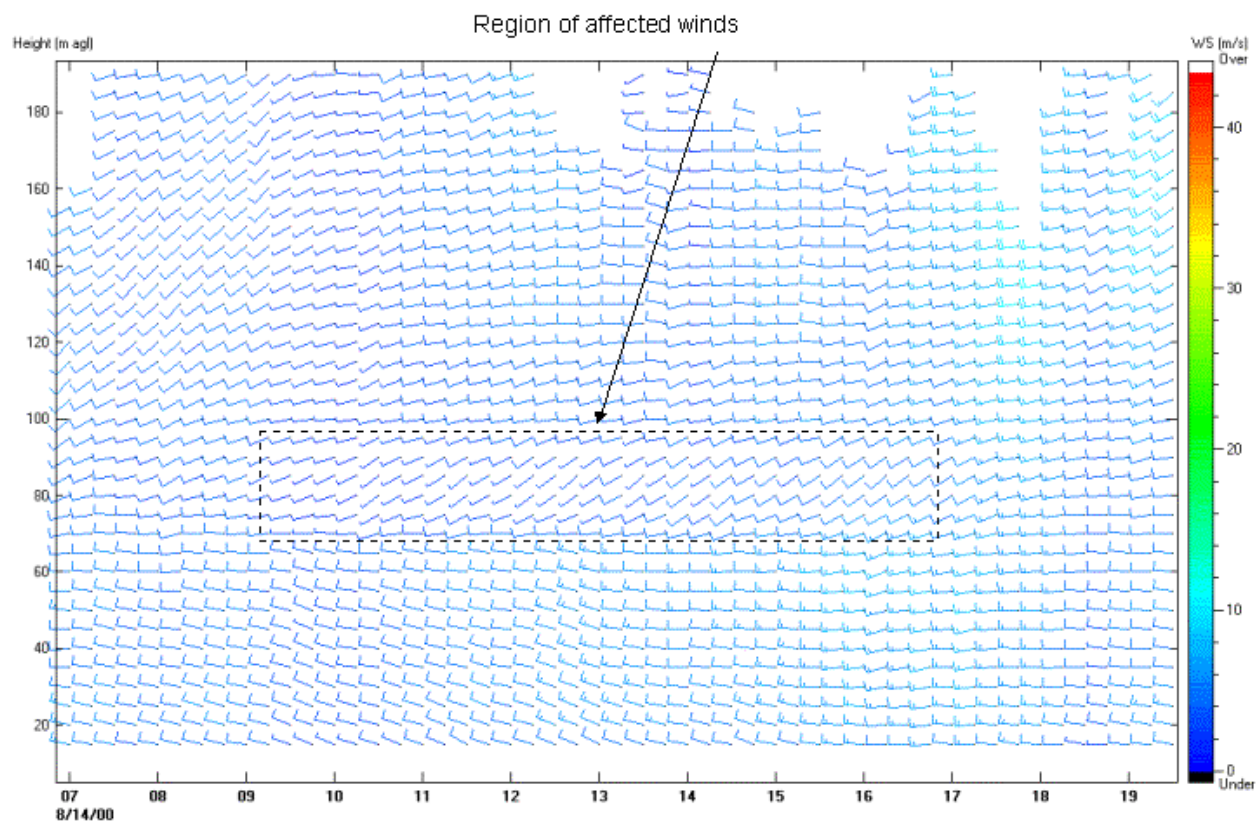


Figure 5-2. Sodar Data Showing the Effect of Reflections on the Data in the 70 to 100 m Range (Parsons, 2002)

6. REFERENCES

Fujita, E., R. Keislar, W. Stockwell, D. Freeman, J. Bowen, R. Tropp, of Desert Research Institute and S. Tanrikulu and A. Ranzieri of California Air Resources Board (2000) Central California Ozone Study (CCOS) Vol. III: Final Report. Prepared with extensive input from CCOS Field Study Participants, Technical Committee, Scientific Advisory Work Group, Meteorological Work Group, and Emission Inventory Coordination Group, February 2001.

Parsons Engineering Science (2002) Final Quality Assurance Audit Report for Central California Ozone Study (CCOS). Prepared by Parsons Engineering Science, Inc. for San Joaquin Valleywide Study Agency and California Air Resources Board, June 2002.

APPENDIX A

Field Forms

CCOS
BAAQMD AQ SITES
NOy Analyzer Field Inspection
T&B Systems

Site _____ Technician _____

Date _____
Time _____ Inst Number _____

Visual Inspection

Inst Op _____	Mast _____	
Power _____	Sample Lines _____	Purafil _____
DL _____	Vac Pump _____	
Alarm _____	Compressor _____	Drain _____

Data Dump File _____ Time DL/ Act _____
Incl Dates _____ Data Module _____ / _____

Before Filter Change Time _____ **After Filter Change** Time _____

Display NO _____	DL NO _____	Display NO _____	DL NO _____
NO2 _____	NO2 _____	NO2 _____	NO2 _____
NOy _____	NOy _____	NOy _____	NOy _____

Instrument Parameters

Instrument Range _____
V DL Battery _____
DL Int Temp _____

Flow NO Bypass _____
NOy Bypass _____

T/P On _____ OFF _____

Range _____

Coefficients

NO _____

NO2 _____

NOy _____

Offline _____ to _____

Temperature

Internal _____

Chamber _____

Cooler _____

Converter _____

Conv Set _____

Flows

O3 #1 _____

Sample #1 _____

O3 #2 _____

Sample #2 _____

O3 #3 _____

Sample #3 _____

Comments :

CCOS
BAAQMD AQ SITES
O3 Analyzer Field Inspection
T&B Systems

Site _____

Technician _____

Date _____
Time _____

Inst Number _____

Visual Inspection

Inst Op _____
Power _____
DL _____
Alarm _____

Mast _____
Sample Lines _____
Sample Pump _____

Data Dump File _____ Time DL/Act _____
Incl Dates _____ Data Module _____ / _____

Activities _____

Before Filter Change

Filter Change Time _____
Display O3 _____ DL O3 _____

After Filter Change

Display O3 _____ DL O3 _____

Instrument Parameters

Instrument Range _____

Frequency A _____

Noise A _____

Sample Flow A _____

Frequency B _____

Sample Flow B _____

Noise B _____

T&P Corr On _____ Off _____

Test P _____

T _____

Thumbwheel

Span _____

Test A/B _____ / _____

Offset _____

Offline _____ to _____

Comments:

Site _____ Technician _____

Date _____ Inst Model _____

Time _____ Inst Number _____

Calibrator Settings S/N _____

Time **ON** _____

Time **Stable** _____

Flow _____

Sample _____

Total _____

T/P **ON** _____ **OFF** _____

Comments:

[illegible]

CCOS
BAAQMD AQ SITES
Calibration Summary
T&B Systems

Site _____ Time Period _____

Parameter _____ Date _____
Inst Number _____ Signature _____

Calibration Factors Include _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

Date From _____ Time _____ Slope _____ Zero _____

Date To _____ Time _____

CCOS
BAAQMD AQ SITES
Data Validation
T&B Systems

Site _____

Date _____

Parameter _____

Signature _____

Inst No _____

Invalid Sequence

Date	Start Time	Stop Time	Cause
-------------	-------------------	------------------	--------------

T & B SYSTEMS SOUNDING FLIGHT LOG

Launch Information

Station Name: Granite Bay Station ID (SSS): GRB
 Date(mm/dd/yy): 09/30/00 Flight Name (SSSmddhh): GRB93005
 Scheduled Launch Time(Local): 0500 Actual Launch Time(Local): 0456
 Operator(s): DK, DL

Surface Information

Station Elevation(m-msl): _____
 Station Lat. (°' ") : _____ Long. (°' ") : _____
 Station Pressure (inches): _____ (mb): 997.7
 Station Wind Direction: 090 Speed(m/s): 1.9
 Station Temp. (°C): 17.4 RH(%): 75 Enter NA if not available
 Cloud(type,%): CLR Weather: _____

Loran Information

Primary

Secondary

Station 0 TD: _____	SNR: _____	TD: _____	SNR: _____
Station 1 TD: _____	SNR: _____	TD: _____	SNR: _____
Station 2 TD: _____	SNR: _____	TD: _____	SNR: _____
Station 3 TD: _____	SNR: _____	TD: _____	SNR: _____
Station 4 TD: _____	SNR: _____	TD: _____	SNR: _____
Station 5 TD: _____	SNR: _____	TD: _____	SNR: _____

Theodolite Information

Station Reference AZ(°): _____	EL(°): _____
Preflight Check AZ(°): _____	EL(°): _____
Postflight Check AZ(°): _____	EL(°): _____

Radiosonde Information

Serial #: 2474811
 Sonde Temp. (°C): 12.2 RH(%): 77
 Thermistor Lockin(ohms): _____ Hygistor Lockin(ohms): _____
 Sonde Frequency(MHz): 404.1 Signal Strength: 255
 Initial Sonde Press.(mb): 998.0 Pressure Correction(mb): -0.4
 First Time Value in Edit Launch Mode (mm.ss): - 01.55

Comments

$T_{850} = 22.5$
 1st Sounding at
 this TAP

O₃ sonde S/N 205317
 Flow rate = 29.1
 Background R = 0.01
 Zero Filter = 1.0
 GROUND TRUTH
 sonde = 34.7
 monitor = 37.6

OZONESONDE - - MICROSONDE DAY OF LAUNCH ASSEMBLY
CCOS SUMMER 2000

Flight File # 62893005

PRIOR to INTERCONNECTING Ozone and MICROSONDE units:

- ___ Prepare batteries per package instructions. Check proper polarity (orange is + & at point).
- ___ Record Microsonde S/N: 2474811 O3 Sonde # Z 05317
- ___ Retune Microsonde transmitter frequency if needed
- ___ Place the O3sonde box next to the Microsonde so the tape spots (do not stick yet) face the Microsonde and the humidity shield side is opposite the O3 box side
- ___ Complete installation of wires under the shield. Shield side faces the Microsonde.
- ___ White/blue wires to P3 (W=white, B=blue) They "snap" a little when in properly.
- ___ Yellow/black wires to P1 with the black on the "P1" side
- ___ Orange/black wires to P2 with the black on the "P2" side
- ___ Slide on shield with y/b, o/b pairs out the closest shield upper slots. Beware not to pinch the b/w sensor lead wires. There's a small gap at the base of the pump frame.
- ___ Connect the short end of orange/black wires to pump red/black wires
- ___ Place (don't adhere yet) internal thermistor (green/blue) inside O3 box so it doesn't short out or contact moving pump parts. Carefully bend the thermistor from the sticky side so it measures internal air temperature without the wires shorting or contacting anything.

FINAL INTERCONNECTION OF OZONE AND MICROSONDE

- ___ Connect ambient intake tube to pump and verify all other tubing and caps are correct.
- ___ Place O3 apparatus into flight box oriented so metal shield faces Microsonde.
- ___ O3 box tape spots face Microsonde. Use tape to hold wires and tube at slots.
- ___ Orange/black wires go over motor and out slot in box cover over O3 box battery space.
- ___ Ambient sample intake tube goes in deeper slot opposite battery space side.
- ___ Yellow/black and green/blue wires go in slot on Microsonde side.
- ___ Place batteries in plastic bags and place in appropriate sonde spaces
- ___ NOTE if polarity is reversed the O3 sonde pump will run backwards pumping out the Cathode solution and spoiling it for launch until fully cleaned and reprepared.
- ___ Connect the O3 sonde battery and verify proper air flow in entire system.
- ___ Connect the Microsonde battery. Follow ZEEMET procedures thru signal acquisition.
- ___ Verify a match on ZEEMET. The sondes may need to be moved and antenna oriented.
- ___ Final Check of O3 sonde interior. Double check tube connections and air flow.
- ___ Remove sticky pad covers, stick the 2 sondes together (for best wire run) & thermistor.
- ___ Place lid on and TAPE SECURELY the LID HOLDS IT ALL. Do two runs of tape all around the lid and bottom of box. Place tape to secure batteries and hold wires close to box to avoid snagging balloon line. Tape over the gap between sondes base and sides.

The Balloon should be ready and tethered at launch site. Have a stand ready to set the sonde on while connecting the balloon and verifying ground data. Run line and LORAN antenna from Microsonde thru ring on O3 sonde lid to balloon/parachute. Use brake pin to release and lock line. Do not let out all of the line so there can be about 50 cm of extra LORAN antenna. Continue with ZEEMET launch procedure.

SUMMARY OF PREFLIGHT PREP. DATA needed for W-9000 ZEEMET OPERATION

Air Flow rate 28.7 sec/100ml Cathode sol. vol. 30 ml Backgnd 0.01 micro A
OZsopPrep3+080400

OZONESONDE -- CHECK LIST AND DATA TRANSCRIPTION -- CCO S SUMMER 2000

"DAY OF LAUNCH" PREPARATION (Ideally less than 24 but up to 48 hrs prior to flight)

O3 SONDE #: Z 05317 Date 09/29/00 ^{FOR} Site/Tech GRB Flight File #: _____
Start HI O3 / end HI O3 / end NO O3

CONDITION PUMP and CHANGE SENSOR SOLUTIONS

HI O3 Conditioning of pump & tubes start/stop time (15 min) 1740 / 1750 / 1755 (pdt) pst?

(purge with NO O3 for 5 minutes before placing cathode tubes into cell)

Flush CATHODE (fill D H₂O & mt) refill with 6.0 ml cathode solution and note time: 1742

(rinse syringe every step) CATHODE SOLUTION VOL = 3.0 ml

MT Cathode, rinse syringe D₂ H₂O, refill Cathode w 3.0 ml Cathode Solution, note time: 1744

Flush ANODE (Vol extracted: 1.5) and refill with 1.5 ml Anode Solution, note time: 1746
(rinse syringe before with D₂ H₂O and after with D H₂O)

Start NO O3 mode conditioning (cathode tubes now in cell) note time: 1755

After 10 minutes of NO O3 note Sonde Pump Voltage 12.3 V dc, and current 69 milli A

SENSOR AIRFLOW RATE

Test results (time for 100 ml of flow in sec) 29.0 28.6 28.5 Average 28.7

Ambient conditions of test: 24 dry T 16 wet T 29.77 pressure Need Cor ? Y / (N)

SENSOR BACKGROUND CURRENT

Measure after 10 minutes plus of NO O3 flow (time: 1805) CURRENT: 0.01 micro A

Now turn on the O3 lamp for 10 min. warm up (rod fully in) and note the time: 1755

SENSOR RESPONSE TEST FOR OZONE INCREASE (LO O3 mode)

Pull out Rod for 5.0 micro A and after exactly one minute note the Current 5.00 micro A

SENSOR RESPONSE TEST WITH OZONE DECREASE (LO O3 mode)

Fine tune O3 control rod to 5.00 +/- 0.05 micro A and operate for 10 min. +. Start/stop: 1810/1820

STOPWATCH TIMED TEST

00 sec = i_0 = 4.97 micro A

COMPUTE

30 sec = $i_{0.5}$ = 1.40 micro A

If $i_1 < \text{or} = 0.2 (i_0 - i_{10})$

1 min = i_1 = 0.45 micro A

0.45 < or = $0.2 (4.97 - 0.03)$

3 min = i_3 = 0.08 micro A

0.45 < or = 0.988

5 min = i_5 = 0.05 micro A

Circle one (for dramatic effect) (YES!) NO!

10 min = i_{10} = 0.03 micro A

If YES continue into prelaunch.

If NO use another O3 sonde

OZsopPrep3+080400

OZONESONDE - - CHECK LIST AND DATA TRANSCRIPTION - - CCOS SUMMER 2000

PREFLIGHT PREPARATION 3-14 DAYS PRIOR TO RELEASE

Flight File Number: _____

Sonde Assembly - - Factory Label Data

ECC Sonde # Z 05317 3 cks ✓ ✓ ✓ Date Manufactured 6/00

Pump Volts 12.3 V d.c. Pump Current 65 mA

Press./Vac. 25 / 21 in Hg Air Flow 29.1 / 29.1 sec / 100 ml

Date / Time inspected and installed circuit board 27 SEP 00 / 18:02 local st or (dt?)

Pump Test and Conditioning

NO O3 10 min run Start time 19:13 Voltage 12.2 V dc Pump Current 75 millia

Pump Outlet Pressure 14.5 (> 8.8 psi) Inlet Vac 27.5 (> 20 in Hg) End Time 19:24

HIGH O3 30 min Start/Stop Time 19:25 / 20:03 NO-LO 5 min times 20:03 / 20:24

Sensor Charge

Cathode Charge Time 20 : 26 : 16 Anode Charge Time 20 : 28 : 26
(2 min. after Cathode)

Date Charged: 27 SEP 00

20:30 - 20:43
Sensor current after 10 min 0.03 micro A. Sensor disconnect time: 20:43

Preliminary Sensor Response Tests

One hour or more conditioning period end date: 28 SEP 00 time: 17:08

NO O3 5 min start time: 17:09 INITIAL Sensor Background Current: 0.03 micro A
(<0.3 micro A)

Turn on UV lamp and allow to warm up for 5 minutes 17:15:20

LO O3 1 min climb point PRELIMINARY Sensor Response Current: 4.68 micro A
17:20:45 = 0.02 17:21:00 = 2.16 17:21:15 = 3.64 17:21:30 = 4.37 (4-5 micro A)

NO O3 1 min drop off 5.0 mA Sensor Response Off Current: 0.41 micro A (< 1.5 mA)
17:23:00 = 4.96 17:23:15 = 2.70 17:23:30 = 1.25 17:23:45 = 0.72

NO O3 ten minute Purge start/stop times 17:24:30 / 17:34:30
0.19 0.02

Storage

Date and Time stored (+3 ml cathode sol.) 28 SEP 00 / 17:36

NOTES: circuit board 035 B REV A AMI 0008

Pump assembly was missing one brass nut - just a screw was present
substituted an extra silver nut.

OZsopPrep3+080400

OZ sonde SN: 205069

OZONESONDE --- CHECK LIST AND DATA RECORD

CCOS SUMMER 2000

FLIGHT FILE NAME _____

DAY OF LAUNCH PROCEDURE

Date 07/22/00 Station MOD Operators WRK

CONDITION PUMP AND CHANGE SENSOR SOLUTIONS

HI O3 Conditioning of pump and tubing start/stop time (15 min) 1340 / 1355 pst

Flush CATHODE and refill with 6.0 ml of cathode solution and note the time 1348

Flush cathode again and refill with 3.0 ml of cathode solution and note the time 1350

Flush ANODE and refill with 1.5 ml of anode solution and note the time 1353

Start NO O3 mode conditioning and note the time 1400

Turn on the O3 lamp for warm up (rod fully in for NO O3) and note the time 1400

After 10 minute of NO O3 note Sonde Pump Voltage 12.3 and current 75

SENSOR AIRFLOW RATE

Test results (time for 100 ml of flow in sec) 29 29 29 Average 29

Ambient conditions of test: 25 dry bulb ≈ 18 wet bulb 29.90 pressure

SENSOR BACKGROUND CURRENT

Measure after at least 10 minutes of NO O3 operation. CURRENT : .17 micro A

SENSOR RESPONSE TEST FOR OZONE INCREASE (LO O3 mode)

Pull out Rod for 5.0 micro A and after exactly one minute note Current 4.89 micro A

SENSOR RESPONSE TEST OZONE DECREASE (LO O3 Mode)

Fine tune the O3 Control Rod to 5.00 +/- 0.05 micro A and operate for 10 minutes or more.

Fine tuning start time 1435 steady 5.00 +/- .05 micro A 10 min. end time 1445

Stopwatch timed test

00 sec = i_0 = 5.01 micro A

COMPUTE

30 sec = $i_{0.5}$ = 1.78 micro A

If $i_1 < \text{or} = 0.2 (i_0 - i_{10})$

1 min = i_1 = 0.64 micro A

0.64 < or = $0.2 (5.01 - 0.18)$

3 min = i_3 = 0.23 micro A

0.64 < or = 0.966

5 min = i_5 = 0.19 micro A

Circle one: YES! NO!

10 min = i_{10} = 0.18 micro A

If YES continue into prelaunch.

ChkLstCCOSoz071900

If NO use another O3 sonde

OZONESONDE --- CHECK LIST AND DATA TRANSCRIPTION

CCOS SUMMER 2000

FLIGHT FILE NAME _____

PREFLIGHT PREPARATION 3-7 DAYS PRIOR TO RELEASEDate July 8 2000 Station PAR Operator BK**Sonde Assembly -- Label Data**ECC Sonde # 205069 3 cks ✓ ✓ ✓ Date Manufactured 5/00Pump Volts 12.3 V d.c. Pump Current 65 MaPress.-Vac. 26 / 21 in Hg Air Flow 29.5 / 29.4 s/100mlDate/Time assembly completed 8 July 00 / 00:36 local standard time (PST)**Pump Test and Conditioning** Date 8 July 2000NO O3 Phase start time 06:45 pst Pump voltage 12.2 V dc Current 83 mAPump Outlet Pressure 14.8 (> 8.8 psi) Inlet Vac 28 (> 20 in Hg) End time 07:00HIGH O3 Phase start and stop time 07:02 / 07:40NO-LO FLUSH Phase start/stop time 07:41 / 08:17**Sensor Charge**Cathode Charge Time 09:17:55 Anode Charge Time 09:20:10Blue and white lead disconnect time 09:30One hour or more conditioning period end date/time 8 July 2000 / 17:30**Preliminary Sensor Response Tests**NO O3 Phase date 8 July 2000 Elapsed time 17:34 / 17:42Five minute point INITIAL SENSOR BACKGROUND CURRENT 0.11 mA (<0.3 mA)

LO O3 One minute climb point

PRELIMINARY SENSOR RESPONSE CURRENT 4.31 mA (4-5 mA)NO O3 One minute drop point Sensor Current 0.75 mA (<1.5 mA)NO O3 Purge start/stop times 17:48 / 17:58STORAGE Date and Time stored (+ 3 ml cath. sol.) 8 July 2000 18:02 PST

ChkLstCCOSoz070700

APPENDIX B

STANDARD OPERATING PROCEDURE

OZONESONDES

APPENDIX B

STANDARD OPERATING PROCEDURE

FOR EN-SCI MODEL Z ECC-O₃-SOUNDES FLOWN WITH VIZ MARK II RADIOSONDES DURING THE CCOS SUMMER 2000 OPERATIONS

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1.0 OZONESONDE – VIZ

1.1 PREFLIGHT PREPARATION

The Ozonesonde needs to be chemically conditioned 3 to 7 days prior to release. The Ozonesonde is shipped partially disassembled and needs to be assembled prior to initial conditioning. There is performance data from the factory that is recorded on the sonde label that should be transcribed to a permanent record. The circuit board is shipped separately in an antistatic bag. Discharge any static charges from your body before handling. To prevent loss of small parts assemble within a tray. Use nonmagnetic tools. The workplace must be clean, well ventilated, smoke free and well illuminated. Handle with care to prevent contamination.

1.1.1 SONDE ASSEMBLY AND DATA TRANSCRIPTION

- A. Transcribe sonde label data to check form. Confirm that the 3 serial numbers match. Inspect the condition of the sonde and the separately packaged circuit board. Check the wiring, tubing, motor, chambers, platinum and sonde packaging. A small bag contains spacers and nuts for installing the board. Handle static electricity free.
- B. Install the circuit board by first placing the 4 spacers over the long screws. The board will install oriented just one way. Use a small nonmagnetic nut driver (size < 3/16) or small nonmagnetic long nose pliers to install the nuts.

1.1.2 PUMP TEST AND CONDITIONING

- A. Connect the ECC Sonde to the EN-SCI Ozonizer/Test Unit (Test Unit) for NO O₃. Begin Pump Test with the cap off the NO-LO O₃ port, all switches on except 18 V dc and UV lamp. Use small sandpaper strips provided to insert tubing into pump. Insert Sonde pump inlet tube 7 cm into the NO-LO port of the Test Unit. Run for 10 minutes then note the pump voltage (12.3 +/- 0.3 V dc) and current (<100 mA). If these are out of bounds see EN-SCI Manual for possible adjustments.
- B. Keep the pump running and test the Outlet Pressure and Inlet Vacuum at the entrance and exit of the pump using the Gage Provided (Outlet pressure >8.8 psi and Inlet vac. >20 in Hg). Note amps increase under the load. Use 12 V dc switch for sonde on/off.
- C. High O₃ condition just the Sonde pump and its' attached tubing, NOT the Cathode. With cap ON the NO-LO port and cap OFF the HI O₃ port, Air Pump off, UV lamp ON (warm up 3 min) and O₃ Control Rod pulled out to end, remove the Cathode Cap and tubing assembly (The Cathode is the farthest cell from the electronics, has 2 tubes, has the longer tube, has more platinum in a star form and has a Teflon seating rod that the inlet spaghetti tubing must fit over). Connect the tubing to the pump as normal and connect the end of the Cathode cap tubing normally inside the cell to the Laboratory O₃ Destruction Filter. Connect the pump inlet tubing to the HI O₃ port. Make sure tubing connections are snug and condition for 30 minutes.
- D. Turn off the UV lamp, push in the UV rod, turn on the air pump, transfer the pump inlet tube from HI O₃ port to NO-LO port and purge with NO O₃ for 5 minutes. Disconnect Lab O₃ Filter, reinstall cathode cap and recap Test Unit ports.

1.1.3 CHARGE SENSORS

Note that each solution has dedicated and labeled containers and syringes. Use an appropriate waste solution disposal container. Prevent contamination. Pour reagent solutions into an appropriate labeled container in the quantity to be used immediately. Never return reagent solutions to their bottles. Rinse syringes before and after with distilled water and store syringes filled with distilled water. Cathode solution is clear and the syringe has tubing. Anode is yellow with no tubing.

- A. Plug the blue and white sensor leads into the Test Unit. Remove and install caps as appropriate.
- B. Charge the CATHODE FIRST (essential for properly charging the ion bridge). The Anode should be charged 2 minutes (or a few seconds more) after the Cathode so prepare for both.
Remove the Cathode cap. Inject 3.0 ml of Cathode solution into the Cathode cell. (Note: Do not inject solution through the cap tubing as this can damage the platinum) Reinstall the Cathode cap with care to insert the inner tubing over the Teflon rod. Remove the Anode cap and 2 minutes after injecting the Cathode inject the Anode with 1.5 ml of solution. Reinstall the Anode cap. Check that all tubing is connected.
- C. PAUSE. Keep the blue and white leads attached to the Test Unit for 10 minutes. Disconnect blue and white leads and leave unshorted while the charged sensor sets for AT LEAST ONE hour. Place the ozonesonde in its' box and check that all tubing is present and the Caps are reinstalled.

1.1.4 PRELIMINARY SENSOR RESPONSE TESTS

- A. Connect the blue and white sensor leads to the Test Unit. Run for 5-10 minutes in NO O3 mode (as in 1.1.2 A above) and after 5 minutes record the INITIAL SENSOR BACKGROUND CURRENT. It should be <0.3 mA. Keep the pump running.
- B. The PRELIMINARY SENSOR RESPONSE TEST CURRENT is obtained in a test during an exact one minute (60 sec) period. It is a LO O3 test condition obtained by turning on the UV lamp (5 min warm up), inserting the pump inlet tube into the NO-LO Port, air pump on and then extracting the control rod just enough to create ozone to generate 5.0 ± 0.3 micro A current (stable in 3-5 minutes). The distance may vary and should be determined by experiment. It is approximately 1/8 to 3/16 inch beyond the first full diameter scribe mark on the rod visible as it is pulled out. If experimentation is needed obtain a NO O3 mode background current between tests. For the Preliminary Sensor Response Test pull the rod out the distance appropriate for a 5.0 ± 0.3 micro A stable current. Do not stop or change setting during the one minute test duration. After exactly one minute record the current. It should be between 4 and 5 micro A. Keep it running.
- C. Fine tune the O3 Control rod to yield 5.0 ± 0.1 micro A of current. With a steady 5.0 ± 0.1 micro A, for exactly one minute test duration, abruptly push in the O3 control rod fully, turn off the UV lamp and at 60 seconds record the current. The current should be less than or equal to 1.5 micro A.
- D. Run on NO O3 mode for 10 minutes to purge system.

1.1.5 STORAGE PROCEDURE

- A. Add 3 more ml of cathode solution to the cathode cell to fill it about 3/4 full.
- B. Short the blue/white sensor leads (with clip) before storage (keeps conditioning)
- C. Remove batteries if present and store in the flight box with the same S/N. Check that all serial numbers agree, the pump inlet tube is present, the pump outlet tube is connected to the pump and the cell caps are in place.
- D. Record the date and time stored.

1.2 PREFLIGHT FULL SYSTEM TEST OF INTERFACED OZONESONDE, VIZ SONDE AND W-9000 SIPPICAN METEOROLOGICAL PROCESSING SYSTEM.

This procedure is used immediately prior to launch, however, an interface test prior to the day of launch can save critical time on launch day.

1.3 PREFLIGHT PREPARATION -- DAY OF LAUNCH

Day of launch means within 24 to a maximum of 36 hours prior to launch.

These procedures are to recondition the pump and tubing with ozone, empty the old cathode and anode solutions and replace them with fresh solutions, and obtain timely Sensor Airflow Rate, Background Current and Ozone Response data prior to launch. Input to the W-9000 program will include these values. This should be done in a clean smoke free room at 20-25 degrees Celsius. Ambient temperature, humidity or wet bulb temperature and pressure must be recorded.

1.3.1 CONDITION OF PUMP AND CHANGE SENSOR SOLUTIONS

- A. Condition the Sonde pump and tubing only (as in 1.1.2 C.) on HI O3 for 15 minutes.
- B. Flush and renew the CATHODE solution FIRST. Add distilled (DI) water to nearly fill the cathode cell. Then draw it out with the syringe. Rinse the syringe with DI water. Refill the cathode cell with 6.0 ml of cathode solution. Draw it out again, rinse the syringe again, and refill the cell finally with 3.0 ml of cathode solution. Rinse and store the syringe filled with DI water.
- C. Change the ANODE solution. Draw out the old. Rinse syringe with DI water. Add 1.5 ml of anode solution. Rinse and store the syringe filled with DI water.
- D. Run the Sonde for 10 minutes in NO O3 mode (as in 1.1.2 A) except turn the Ozone lamp on (Rod in) so it will be fully warm and stable for items 1.3.4 and 1.3.5 below. During this 10 minute run item 1.3.2 below can be completed. After 10 minutes note the Sound Pump Voltage and Current. They should be comparable to the Sonde Lable readings of item 1.1.2 A. Keep the system running.

1.3.2 SENSOR AIRFLOW RATE

Use a bubble meter to determine the time for 100ml of flow (in seconds). Take 3 readings and enter the average for the program value. Record the ambient room temperature, wet bulb temperature or humidity and pressure. Keep the system running.

1.3.3 SENSOR BACKGROUND CURRENT

The system should have been running on NO-LO O3 condition with the exception of the Ozone Lamp being on (with the rod fully inserted) to warm up. After at least 10 minutes have passed running on NO-LO O3 record the Sensor Background Current. It should be less than 0.20 micro A (stricter than in 1.1.4 A). Continue.

1.3.4 SENSOR RESPONSE TEST FOR OZONE INCREASE

This test repeats 1.1.4 B procedure except the Ozone Lamp has been given more time to warm up and stabilize. Follow the 1.1.4 B procedure. Keep it running.

1.3.5 SENSOR RESPONSE TEST OZONE DECREASE

This test is a more refined version of 1.1.4 C and D. With the Ozone Lamp warm and steady fine tune the control rod to yield a steady 5.0 micro A +/- 0.05. Timing with the stopwatch at Zero turn off the Ozone Lamp and push in the Rod. Take readings of the Current at 30 seconds, 1, 3, 5, and 10 minutes. Note the room temperature. Continue to run the sensor for at least 10 more minutes on purge with Ozone free air. Compute the accept or reject formula on the data sheet. Keep the Sonde running for a final interface check.